PROJECT REPORT
ON

POWER ELECTRONICS: COMPUTER SIMULATION AND ANALYSIS

By:

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B.Tech 8TH SEMESTER
Electrical Engineering.

Under the guidance of

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ELECTRICAL ENGINEERING DEPARTMENT
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA

CERTIFICATE

This is to certify that the thesis entitle, "POWER ELECTRONICS:COMPUTER SIMULATION AND ANALYSIS" submitted by Sh. BYAKTIRANJAN PATTANAYAK (10502030) in partial fulfilment of the requirements for the award of Bachelor of Technology Degree in Electrical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

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Ravishankar Singh
Byaktiranjan Pattanayak
Shankar Kumar

ABSTRACT:

Power electronics is interdisciplinary and is at the confluence of three fundamental technical areas - power, electronics and control, .and is used in a wide variety of industries from computers to chemical plants to rolling mills. The importance of power electronics has grown over the years due to several factors.

Computer simulation can greatly aid in the analysis, design and education of Power Electronics. A computer simulation (or "sim") is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables, predictions may be made about the behavior of the system. In our work towards this we have ensured to bring out the different responses of current and voltage in the power electronics circuits. However, simulation of power electronics systems is made challenging by the following factors:

1) Extreme non-linearity presented by switches,
2) Time constants within the system may differ by several orders of magnitude and
3) A lack of models.

Therefore, it is important that the objective of the computer analysis be evaluated carefully and an appropriate simulation package be chosen.

In view of the above considerations, a SPICE based simulation package PSpice and PSIM have been chosen by us for this very purpose. They have had the detailed device models and have been able to represent the controller portion of the converter system by its functional features in as simplified a manner as possible.

CONTENTS

1 INTRODUCTION TO POWER ELECTRONICS:

POWER ELECTRONICS-

Power electronics is the applications of solid-state electronics for the control and conversion of electric power.

Power electronic converters can be found wherever there is a need to modify the electrical energy form (i.e. modify its voltage, current or frequency). Therefore, their power range from some mill watts (as in a mobile phone) to hundreds of megawatts.

The power conversion systems can be classified according to the type of the input and output power

- AC to DC (rectification)
- DC to AC (inversion)
- DC to DC (chopping)
- AC to AC (cycloconvertion)

RECTIFIER:

A **rectifier** is an electrical device that converts alternating current (AC) to direct current (DC), a process known as **rectification**. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components.

INVERTER:

An **inverter** is an electrical or electro-mechanical device that converts direct current (DC) to alternating current (AC); the resulting AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

Static Inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high-voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

The electrical inverter is a high-power electronic oscillator. It is so named because early mechanical AC to DC converters was made to work in reverse, and thus was "inverted", to convert DC to AC. The inverter performs the opposite function of a rectifier.

CHOPPER:

Essentially, a chopper is an electronic switch that is used to interrupt one signal under the control of another. Most modern uses also use alternative nomenclature which helps to clarify which particular type of circuit is being discussed. These include:

- Switched mode power supplies, including DC to DC converters.
- Speed controllers for DC motors
- Class D Electronic amplifiers
- Switched capacitor filters
- Variable Frequency Drive

CYCLOCONVERTER:

A **cycloconverter** or a **cycloinverter** converts an AC waveform, such as the mains supply, to another AC waveform of a lower frequency, synthesizing the output waveform from segments of the AC supply without an intermediate direct-current link. They are most commonly used in three phase applications. In most power systems, the amplitude and the frequency of input voltage to a cycloconverter tend to be fixed values, whereas both the amplitude and the frequency of output voltage of a cycloconverter tend to be variable. The output frequency of a three-phase cycloconverter must be less than about one-third to one-half the input frequency .The quality of the output waveform improves if more switching devices are used (a higher *pulse number*). Cycloconverters are used in very large variable frequency drives, with ratings of several megawatts.

APPLICATIONS OF POWER ELECTRONICS:

Power electronics applications in power systems are growing very rapidly and promise to change the landscape of future power systems in terms of generation, operation and control. There are basically three most important application areas – distributed generation, flexible AC transmission systems (FACTS) and power quality. It is widely accepted that distributed generation is a very important energy option in the near future. Most of the distributed energy resources require a power electronic converter to interface with the load and utility. FACTS are important due to two main reasons:

- deregulation of utility requires precise control of power flow by FACTS

- and growing energy demand coupled with difficulty in constructing more transmission lines requires FACTS devices to enable increased power flow in existing lines.

2 SIMULATION TECHNIQUES:

The different simulating software applications that have been undertaken by us for the evaluation of the power electronics circuits are as follows:

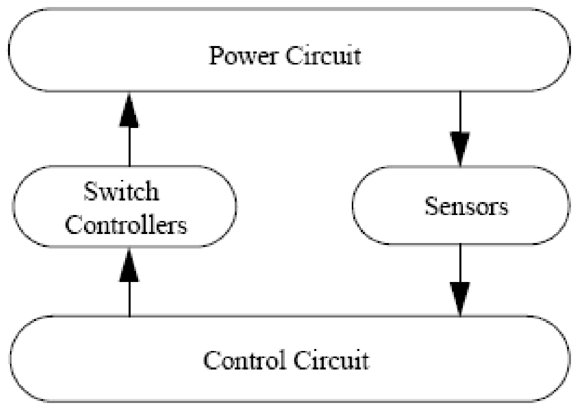
- *PSIM-*
- *PSPICE STUDENT VERSION 9.1-*

1) PSIM:

PSIM is a simulation software specifically designed for power electronics and motor drives. With fast simulation and friendly user interface, PSIM provides a powerful simulation environment for power electronics, analog and digital control, magnetics, and motor drive system studies. Powersim develops and markets leading simulation and design tools for research and product development in power supplies, motor drives, and power conversion and control systems.

Circuit Structure:

A circuit is represented in PSIM in four blocks: power circuit, control circuit, sensors, and switch controllers. The figure below shows the relationship between these blocks



The power circuit consists of switching devices, RLC branches, transformers, and coupled inductors. The control circuit is represented in block diagram. Components in s-domain and z domain, logic components (such as logic gates and flip flops), and non-linear components (such as multipliers and dividers) are used in the control circuit. Sensors are used to measure power circuit quantities and pass them to the control circuit. Gating signal is then generated from the control circuit and sent back to the power circuit through switch controllers to control switches.

2) PSPICE STUDENT VERSION 9.1:

SPICE is an acronym for Simulation Program with Integrated Circuit Emphasis and was inspired by the need to accurately model devices used in integrated circuit design. It has now become the standard computer program for electrical and electronic simulation. The majority of commercial packages are based on SPICE2 version G6 from the University of California at Berkeley although development has now progressed to SPICE3. The increased utilization of PCs has led to the production of PSPICE, a widely available PC version distributed by the MicroSim Corporation whilst HSPICE from Meta-Software has been popular for workstations and is now also available for the PC. One of the reasons for the popularity of Pspice is the availability and the capability to share its evaluation version freely at no cost. This evaluation version is very powerful for power electronics simulations.

PSpice, now developed towards more complex industry requirements, is integrated in the complete systems design flow from OrCAD and Cadence Allegro. It also supports many additional features, which were not available in the original Berkeley code like Advanced Analysis with automatic optimization of a circuit, encryption, a Model Editor, support of parameterized models, has several internal solvers, auto-convergence and checkpoint restart, magnetic part editor and Tabrizi core model for non-linear cores.

COMPARISON BETWEEN PSIM AND PSPICE:

Advantage of PSPICE:

- PSpice allows multiple plots to be viewed simultaneously, such as voltage, power, etc. Also, specific points, such as a voltage at a certain time, can be selected and marked on the output plot in PSpice

- PSpice contains libraries full of specific components with manufacturer specifications. These components are included so the user may obtain realistic simulation results.

- Very simple to represent any electrical circuit, in particular power-electronic circuits.
- A wide library of commercial electric components is available.

Disadvantage of PSPICE:

- PSpice allows the user to select specific components with industry standard part numbers and specifications. Searching for these components can take up more of the user's time when constructing the circuit,

- PSpice is a much more complex circuit simulator

- The setting of the simulation parameters can be critical and difficult to do in order to avoid numerical convergence problems.
- PSpice does not allow data visualization during simulation.

Advantage of PSIM:

- With PSIM's interactive simulation capability, you can change parameter values and view voltages/currents in the middle of a simulation. It is like having a virtual test bench running on your computer.
- You can design and simulate digital power supplies using PSIM's Digital Control Module. The digital control can be implemented in either block diagram or custom C code.
- PSIM has a built-in C compiler which allows you to enter your own C code into PSIM without compiling. This makes it very easy and flexible to implement your own function or control methods.
- You can use the Thermal Module to calculate semiconductor device losses (conduction losses and switching losses) based on the device information from manufacturers' datasheet.

Disadvantage of PSIM:

- The complexity of the block diagram used to simulate the power circuit can increase drastically with the number of semiconductors in the circuit.

Now let's compare one of the circuits using both the simulation softwares i.e. PSIM and PSPICE.

We have taken a basic circuit of 3-phase diode bridge rectifier.

First by using PSIM and then we will go for the PSPICE simulation.

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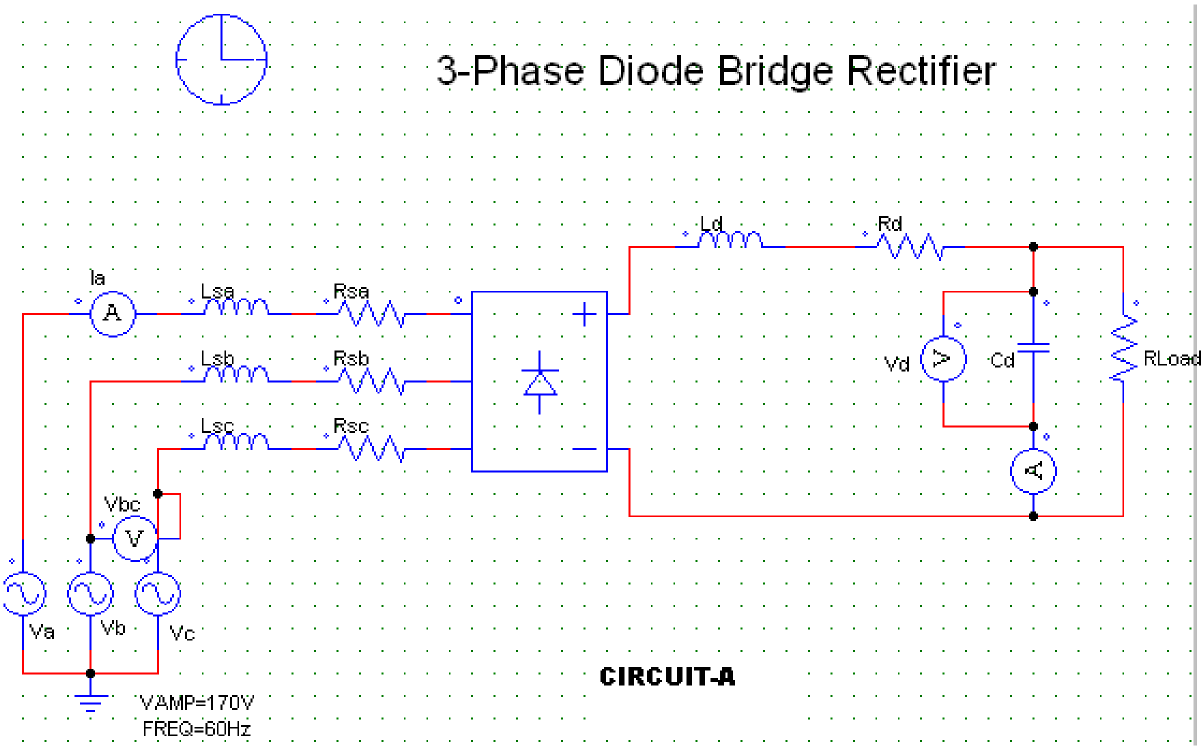
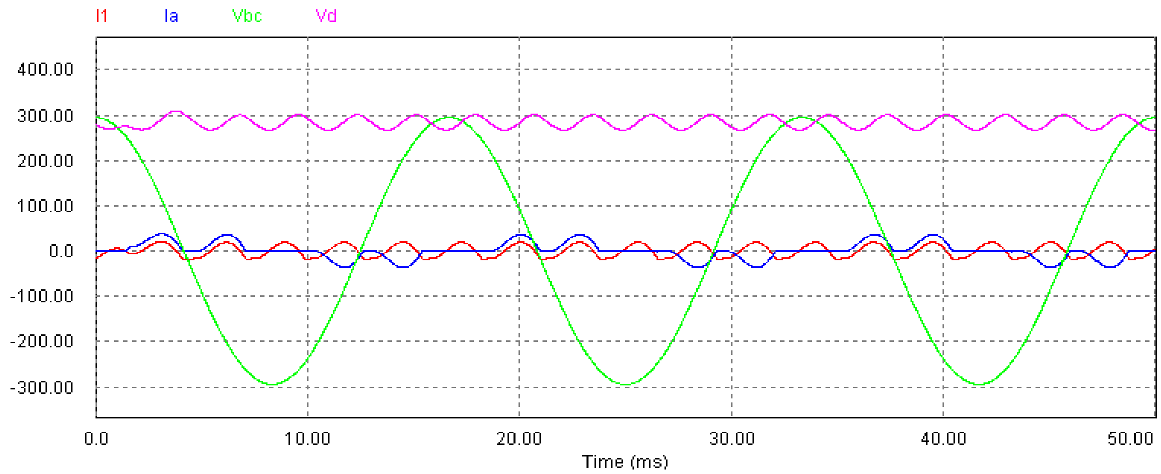
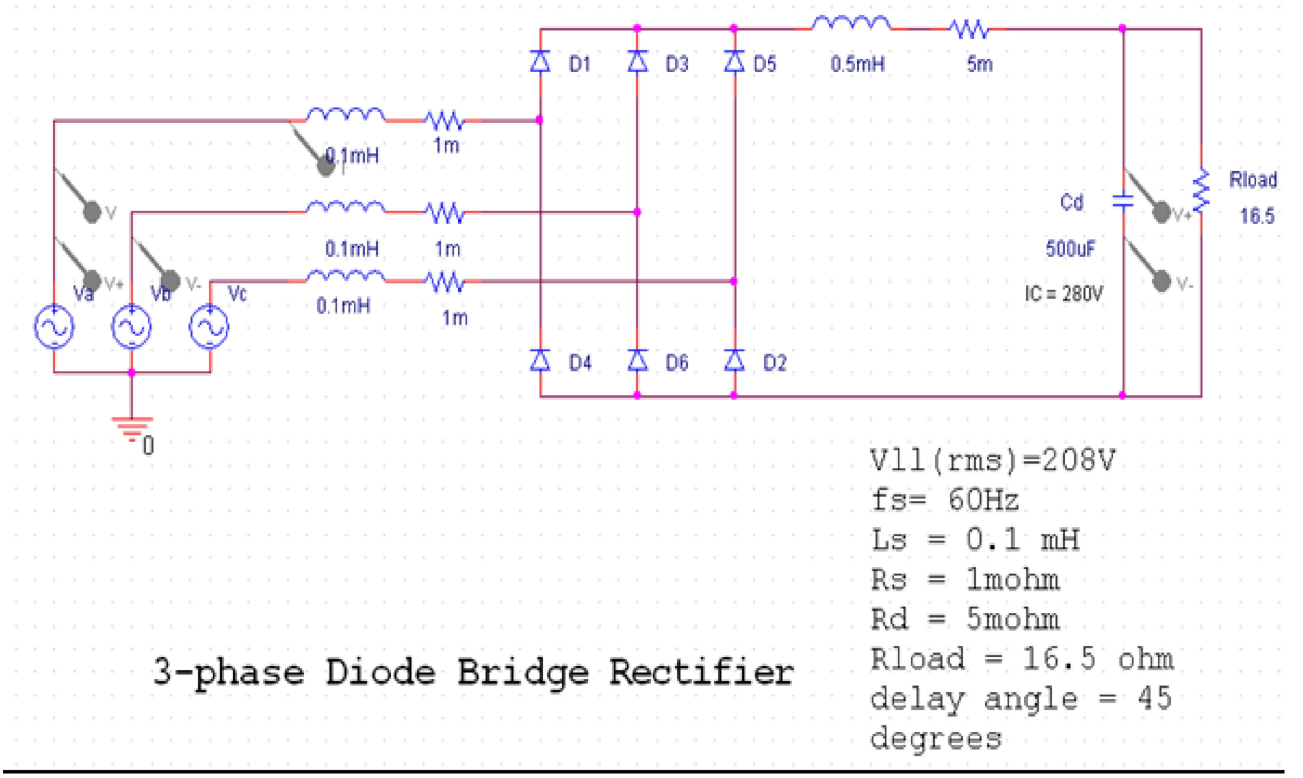
Using PSIM:



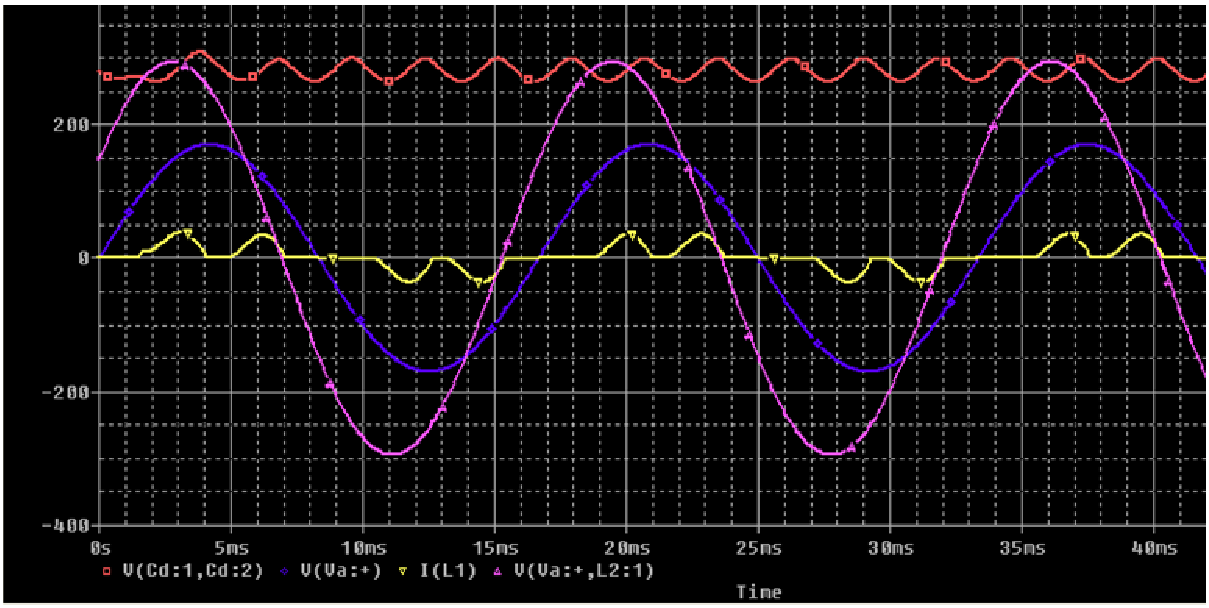


GRAPH A.

__Using PSPICE:__



CIRCUIT-B



GRAPH-B

3. SIMULATION SECTIONS:

Different power electronics circuits have been categorized into different sections and simulations have been carried out for them. What the circuit is all about, the circuit diagram and different voltage and current responses have been mentioned under each section.

Categorization have been done according to the power electronics devices ,starting from the very basic circuits consisting of diodes, then thyristors and then we have moved towards some of the applications of power electronics which basically consists of power supply applications and motor-drive application.

The different sections are as follows:

3.1. Line Frequency Diode Rectifiers

3.2. Line-Frequency Phase-Controlled Converters

3.3 DC-to-DC Switch Mode Converters

3.4 Switch-Mode DC-to-Sinusoidal Inverters

3.5 Resonant Converters: Zero Voltage/Current Switching

3.6 Switch Mode DC Power Supplies with Isolation

3.7 Motor Drives

3.8 Semiconductor Devices

They have been studied in the pages to follow.

3.1. Line Frequency Diode Rectifiers:

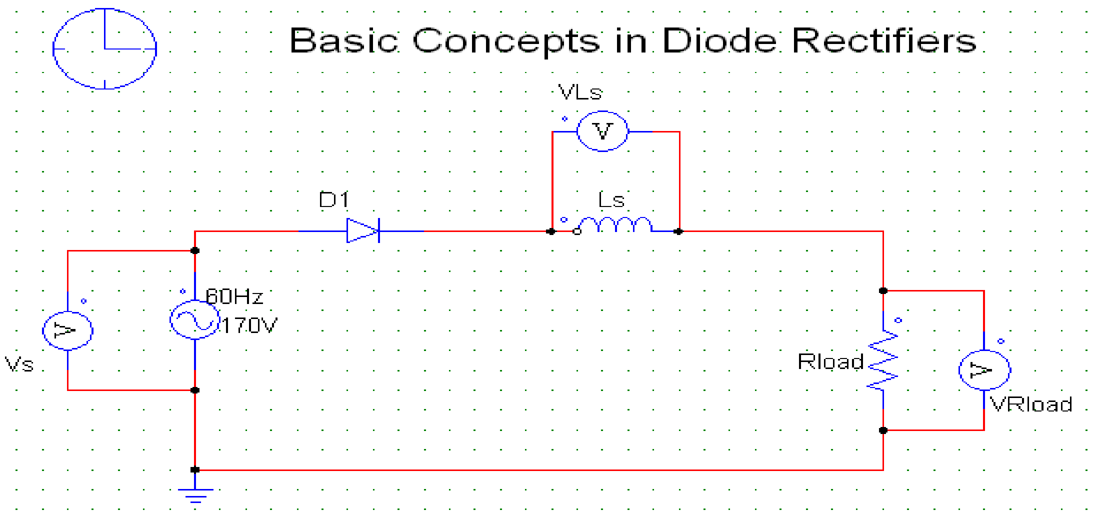
Line frequency diode rectifiers convert line frequency ac. into dc. in an uncontrolled manner. In most power electronic applications, the power input is in the form of a 50-60 hz sine wave ac voltage provided by the electric utility, that is first converted to a dc voltage. Increasingly, the trend is to use the inexpensive rectifiers with diodes to convert the input ac into dc in an uncontrolled manner, using rectifiers with diodes. In such diode rectifiers, the power flow can be only from the utility ac side to the dc side. A majority of the power electronics applications use such as switching dc power supplies, ac motor drives, dc servo drives and so on use such uncontrolled rectifiers.

Circuits-

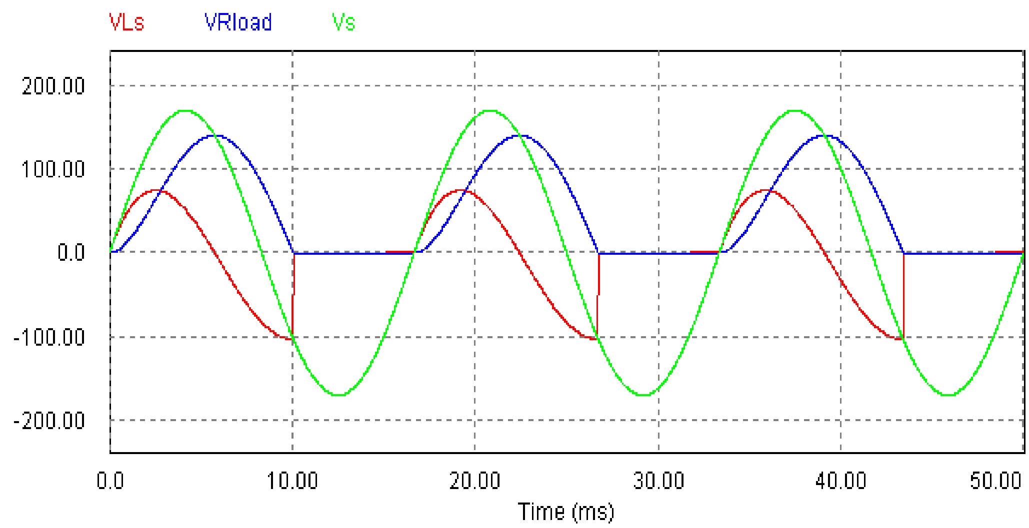
1) Basic concepts in diode rectification
2) Basic concepts of current commutation in rectifiers.
3) 1-phase diode bridge rectifier
4) 1-phase voltage doubler rectifier.
5) Mid-point rectifier.
6) Current in neutral wire due to power electronic loads.
7) 3-phase diode bridge rectifier.

1) BASIC CONCEPTS IN DIODE RECTIFICATION:

Rectification is the process of conversion of alternating input voltage to direct output voltage. Rectification of ac voltages and currents is accomplished by means of diodes.In diode based rectifiers, the output voltage cannot be controlled



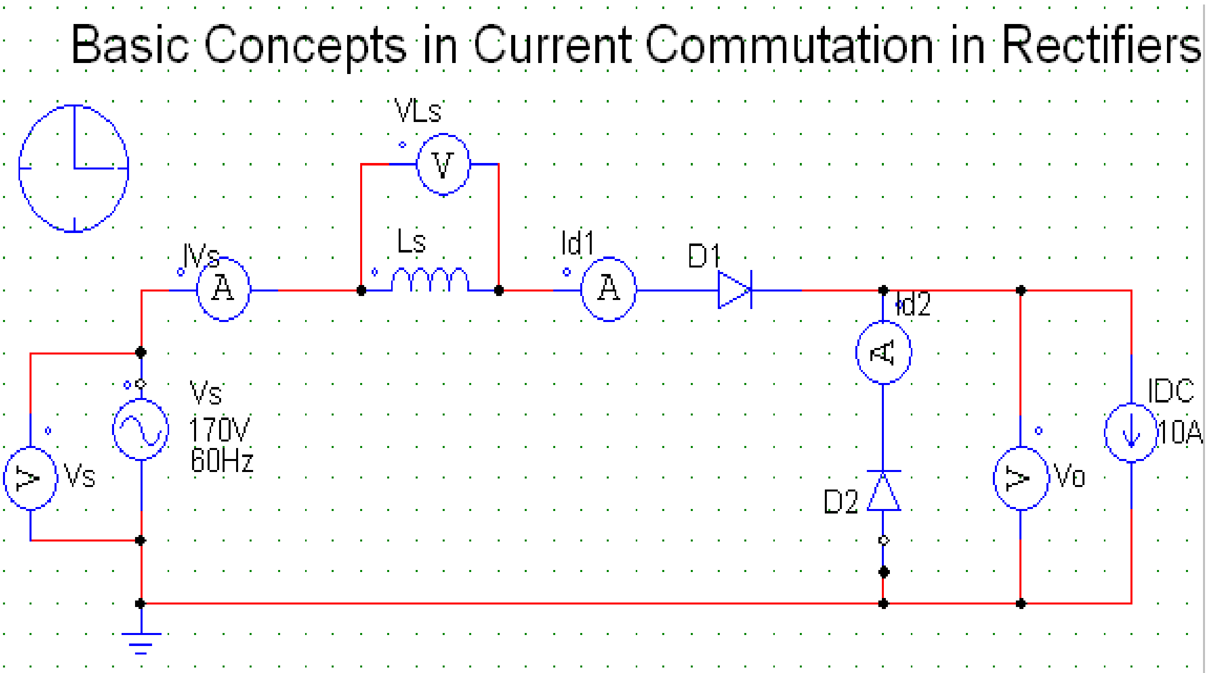
circuit-1



GRAPH-1

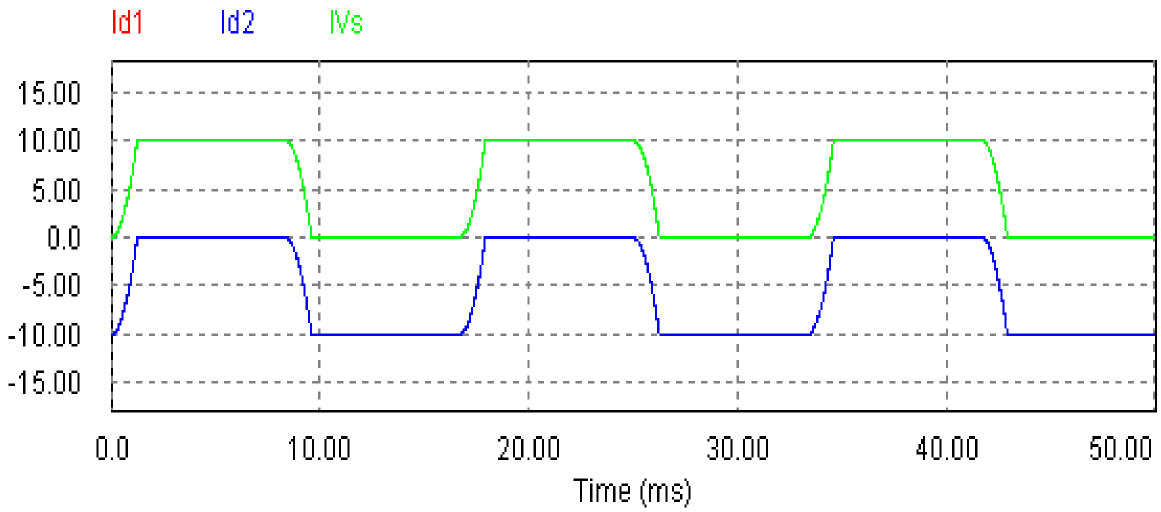
2) BASIC CONCEPTS OF CURRENT COMMUTATION IN RECTIFIERS-

This is for an insight into the effect of a finite ac side inductance Ls on the circuit operation. We assume that the dc side can be represented by a constant dc current Id as shown in the circuit diagram given below. Due to a finite Ls, the transition of the ac-side current Is from a voltage +Id to –Id (or vice versa) will not be instantaneous. The finite time interval required for such a transition is called the current commutation time and this process where the current conduction shifts from one diode to the other is called the current commutation process.

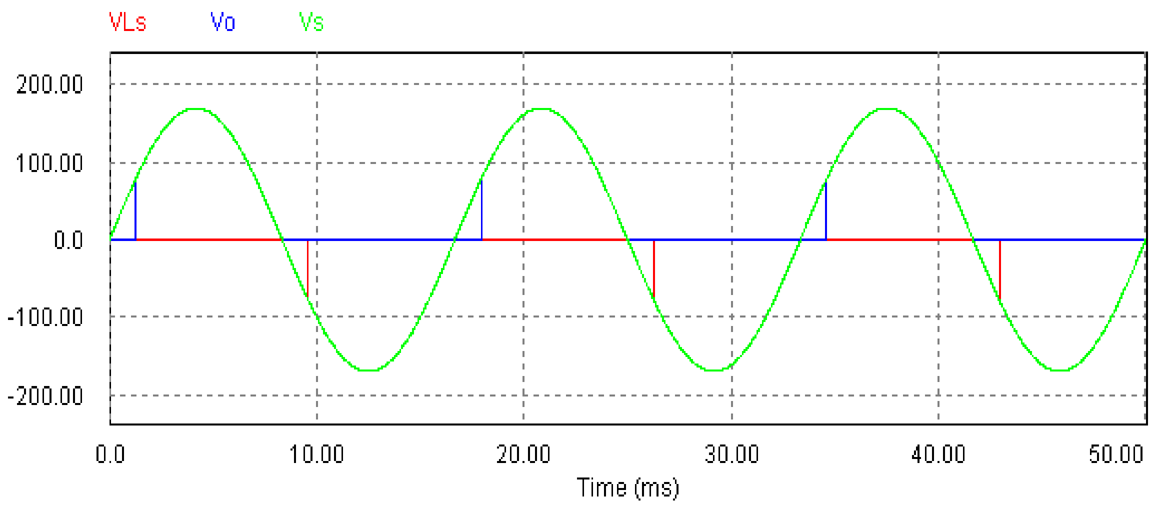


circuit-2

The following two graphs shows the response of both current and voltage of this particular circuit.



GRAPH 2.1 (CURRENT)

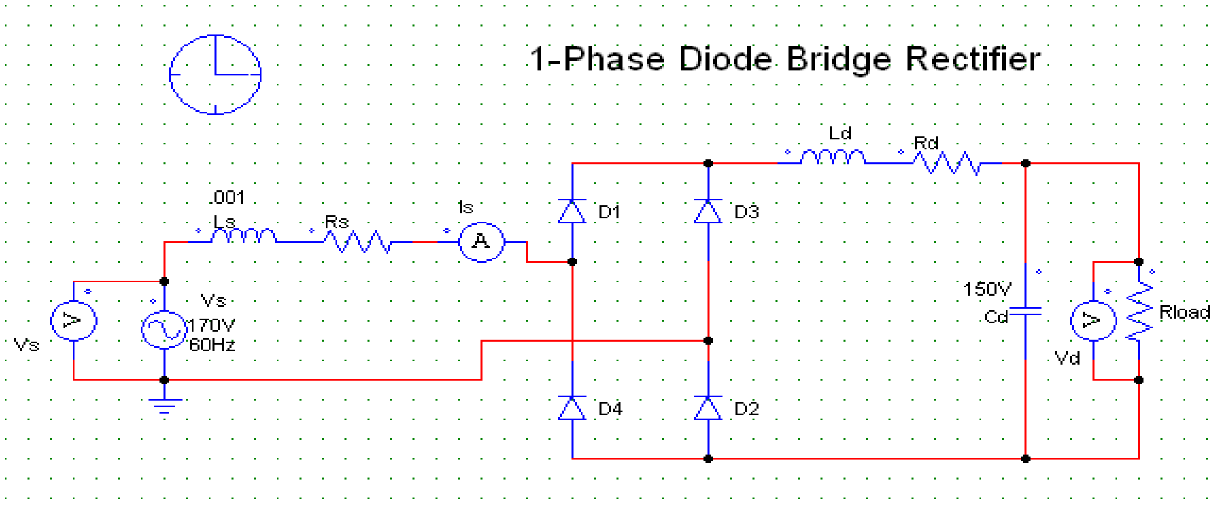


GRAPH 2.2 (VOLTAGE)

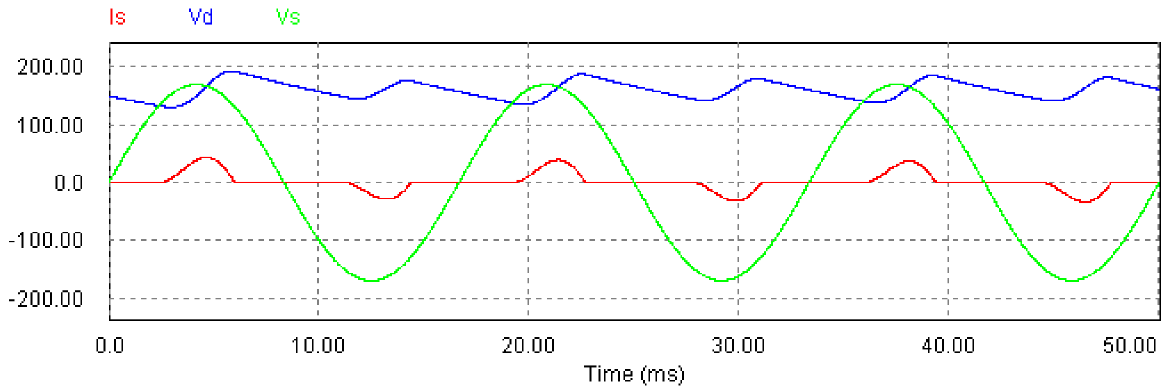
3) 1-PHASE DIODE BRIDGE RECTIFIER:-

A **diode bridge** or **bridge rectifier** is an arrangement of four diodes in a bridge configuration that provides the same polarity of output voltage for either polarity of input voltage. When used in its most common application, for conversion of alternating current (AC) input into direct current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a center-tapped transformer design.

The essential feature of a diode bridge is that the polarity of the output is the same regardless of the polarity at the input.



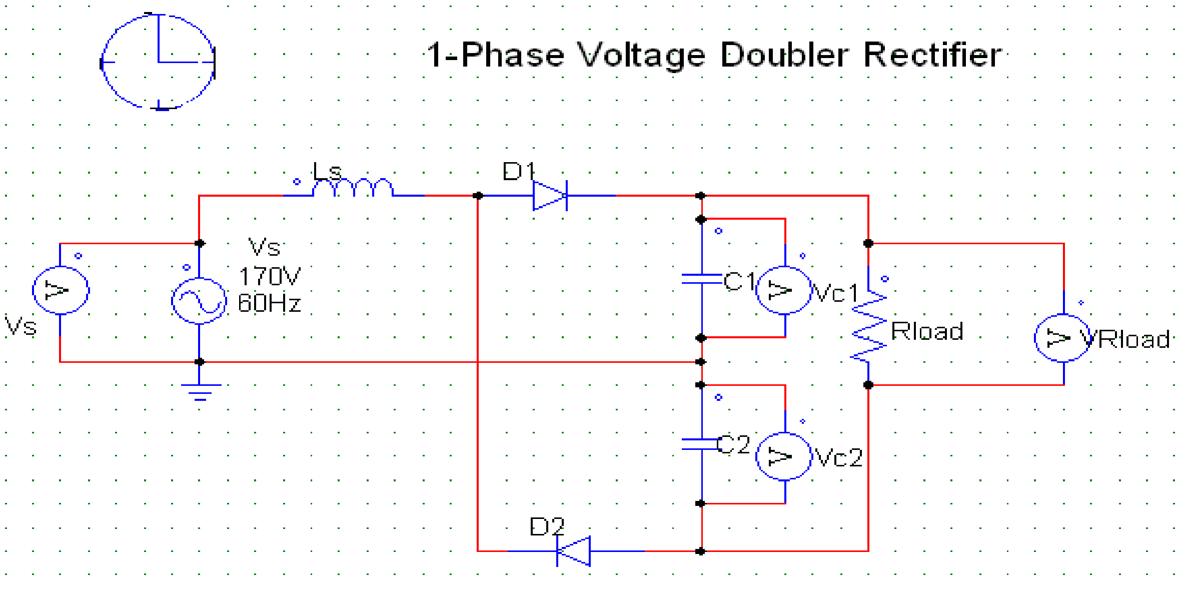
circuit-3



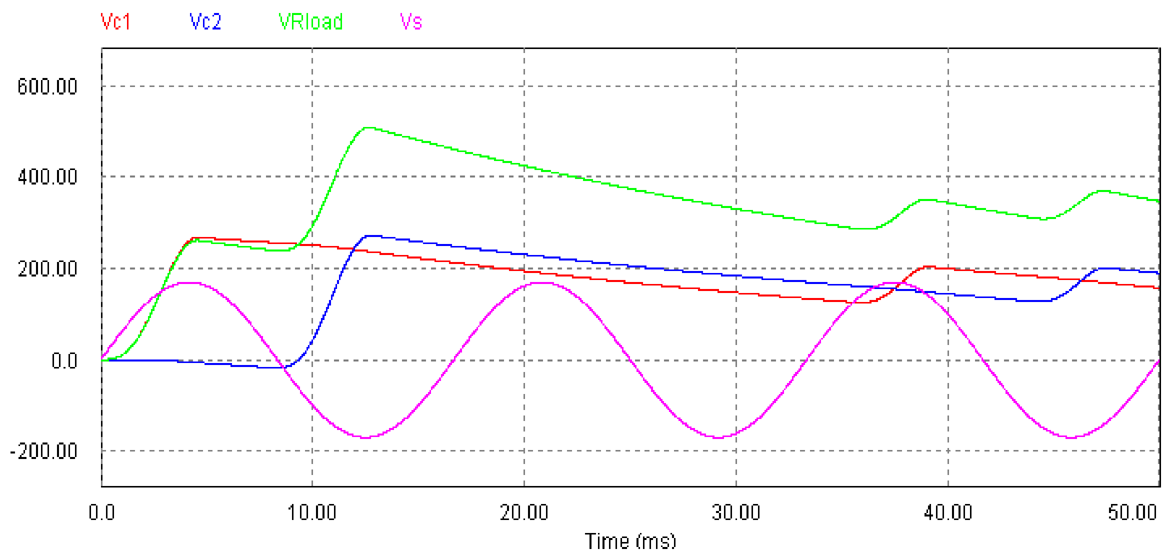
GRAPH-3

4) 1-PHASE VOLTAGE DOUBLER RECTIFIER:

In many applications, the input line voltage magnitude may be insufficient to meet the dc output voltage requirement. More importantly, the equipment may be required to operate with a line voltage of 115 V as well as 230 V. Therefore, a voltage doubler rectifier may be used to avoid a voltage step-up transformer.



circuit-4

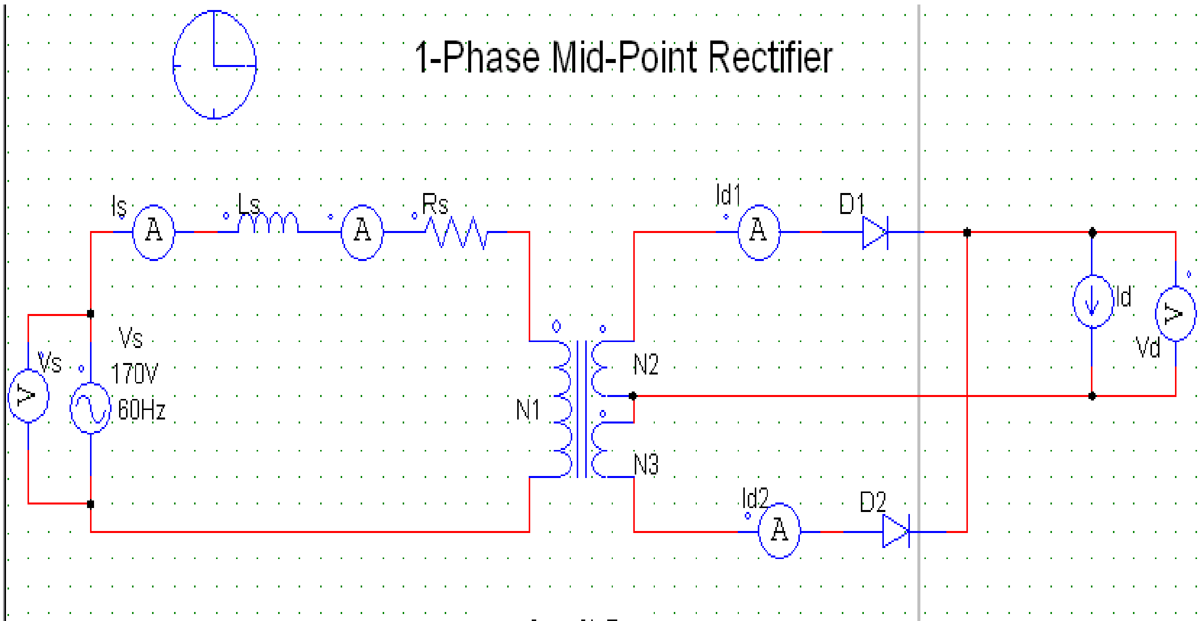


GRAPH-4

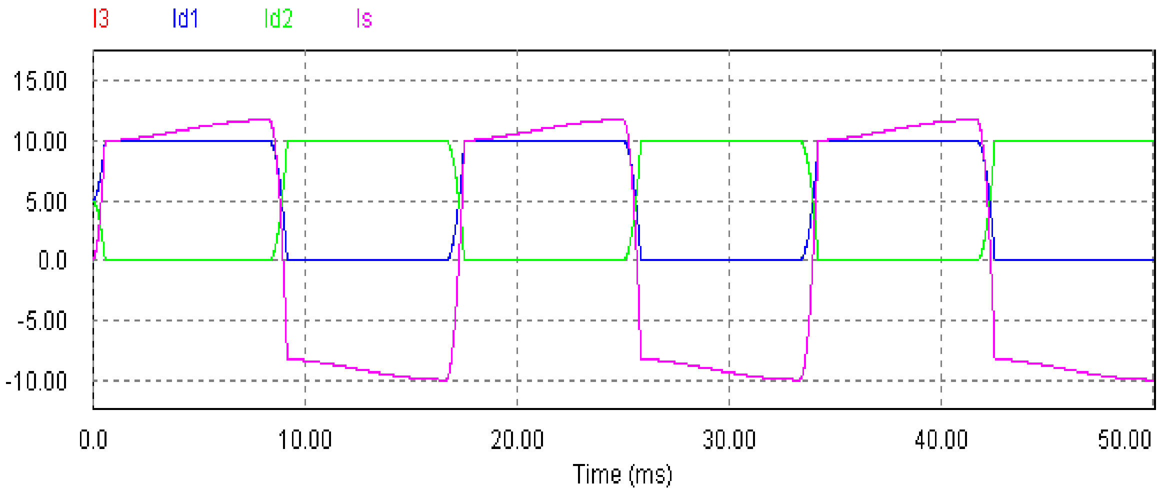
5) MID-POINT RECTIFIER:-

A rectifier with midpoint feed, comprising:

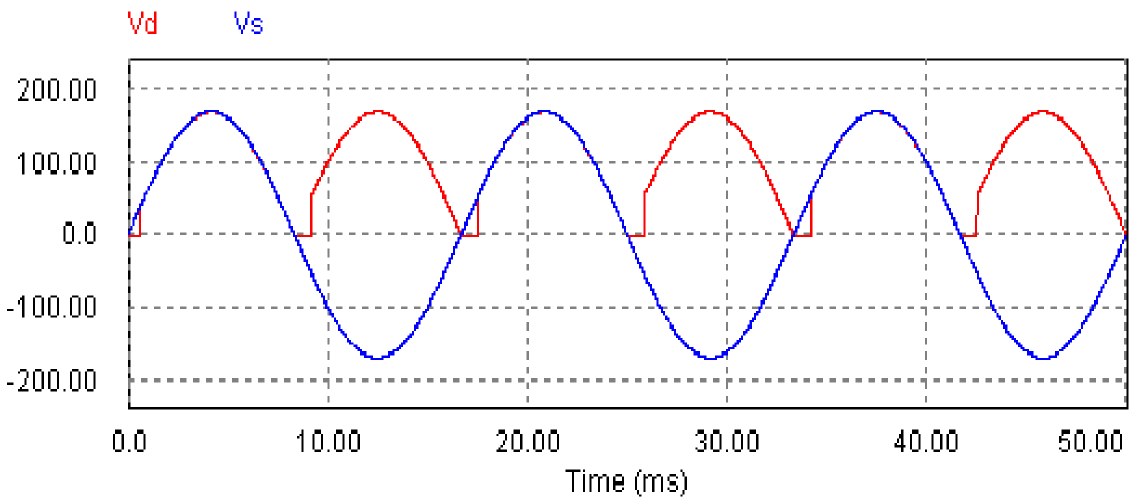
a first and a second input terminal (A,B), which form an input of the rectifier, a first and a second output terminal (P,M), which form a first output of the rectifier, the first output terminal (P) forming the positive pole and the second output terminal (M) forming the negative pole of the first output of the rectifier, wherein a series circuit comprising a first and a second coupling capacitor (C_1, C_2) is arranged in parallel with the first output, the midpoint of the series circuit being connected to the second input terminal (B),wherein a storage capacitor (C_3) is arranged in parallel with a series circuit comprising a first and a second diode (D_1, D_2), the midpoint of the series circuit made up of the first and the second diodes (D_1, D_2) being connected to the first input terminal (A), and the first diode (D_1) being connected to the first coupling capacitor (C_1) via a first inductor, and the second diode (D_2) being connected to the second coupling capacitor (C_2) via a second inductor (L_2).



circuit-5



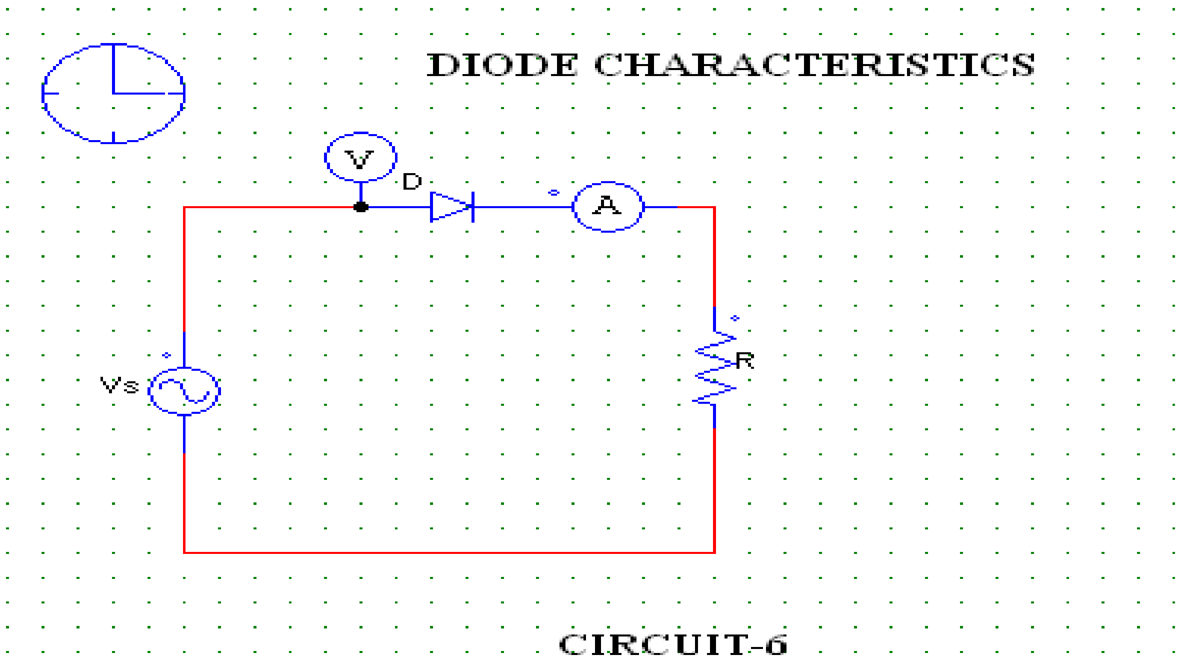
GRAPH 5.1(CURRENT)



GRAPH 5.2(VOLTAGE)

6) DIODE CHARACTERISTICS:-

The graph below shows the electrical characteristics of a typical diode. When a small voltage is applied to the diode in the forward direction, current flows easily. Because the diode has a certain amount of resistance, the voltage will drop slightly as current flows through the diode. A typical diode causes a voltage drop of about 0.6 - 1V (V_F) (In the case of silicon diode (in this case 0.6 v). This voltage drop needs to be taken into consideration in a circuit which uses many diodes in series. Also, the amount of current passing through the diodes must be considered. When voltage is applied in the reverse direction through a diode, the diode will have a great resistance to current flow. Different diodes have different characteristics when reverse-biased.



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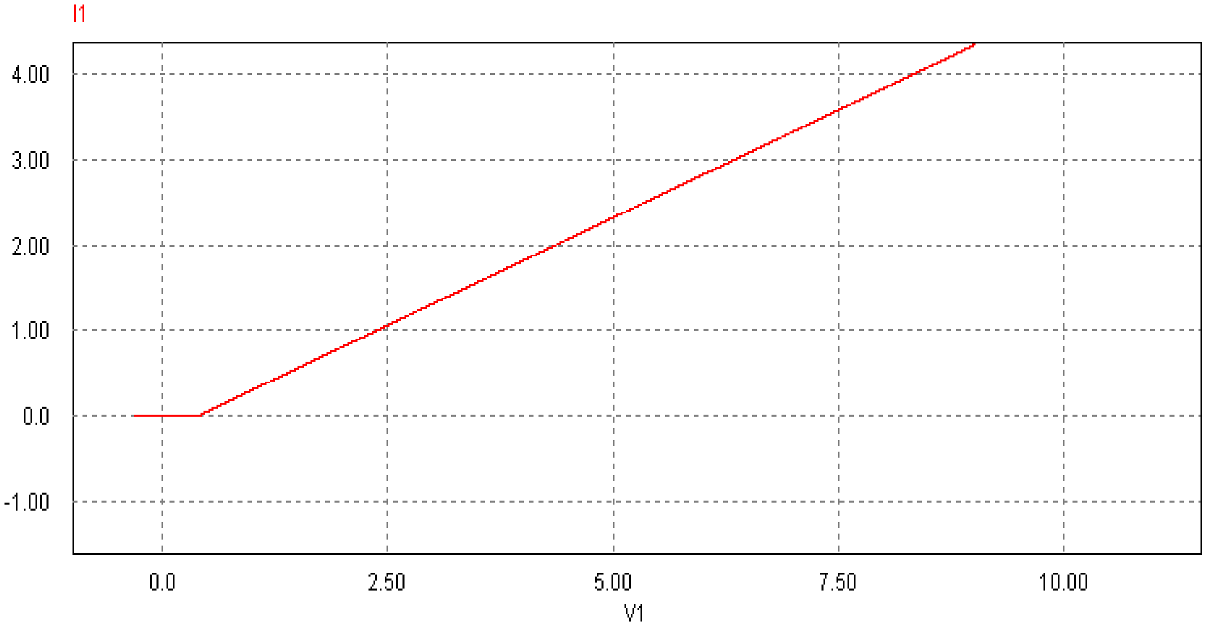
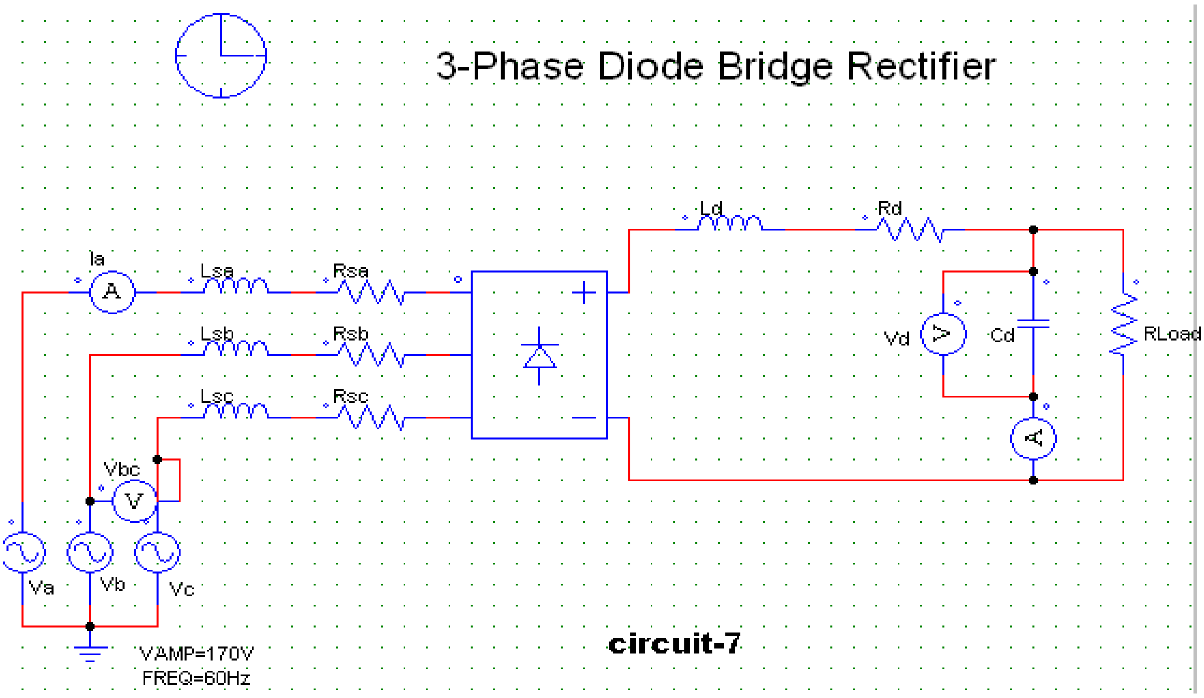
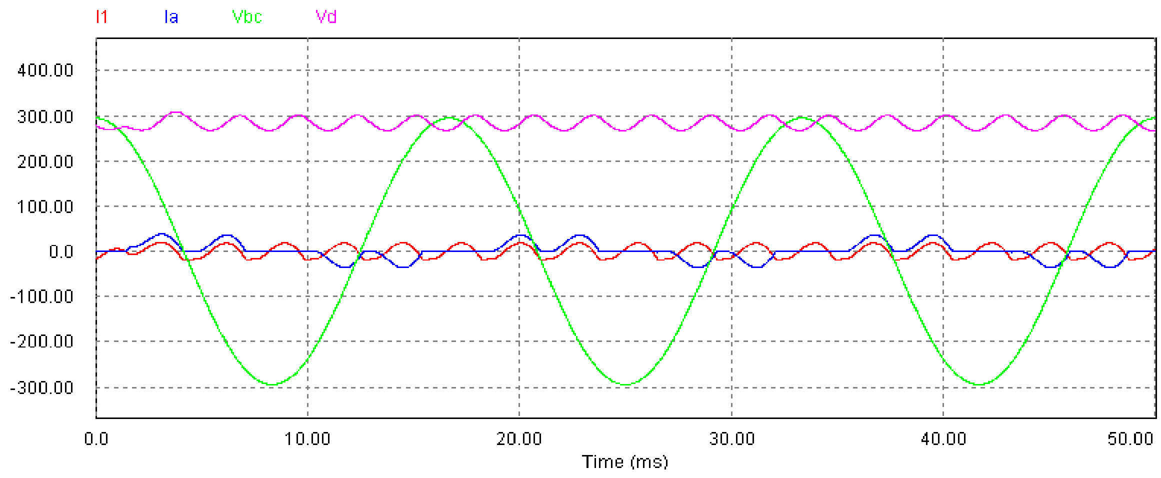


GRAPH-6

7) **3-PHASE DIODE BRIDGE RECTIFIER:-**

In industrial applications where three-phase ac voltages are available, it is preferable to use three-phase rectifier circuits, compared to single-phase rectifiers, because of their lower ripple content in the waveforms and a higher power-handling capability. The 3-phase, 6-pulse, full bridge diode rectifier is commonly used circuit arrangement. A filter capacitor is connected at the dc side of the rectifier.





GRAPH 7

3.2 Line frequency phase controlled converters:

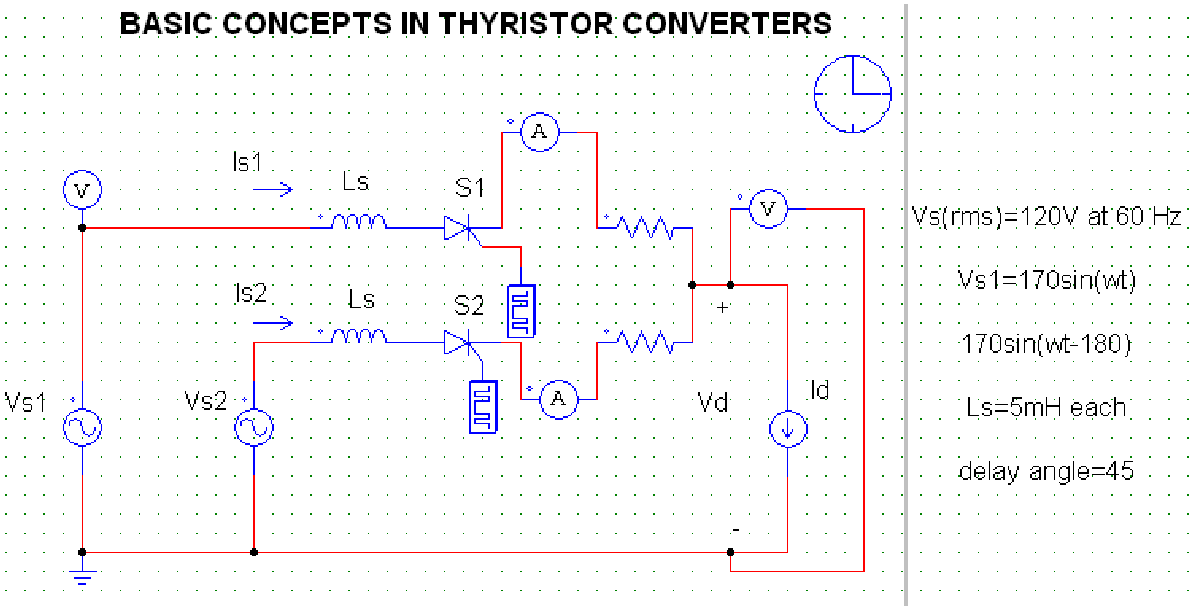
In some applications such as battery chargers and a class of ac and dc motor drives, it is necessary for the dc voltage to be controllable. The ac to controlled dc conversion is accomplished in line frequency phase controlled converters by means of thyristors. These thyristor converters nowadays are primarily in use in 3-phase high power applications. The line frequency voltages are present on their ac side.in these converters, the instant the thyristor begins or ceases to conduct depends on the line-frequency ac voltage waveforms and the control inputs.

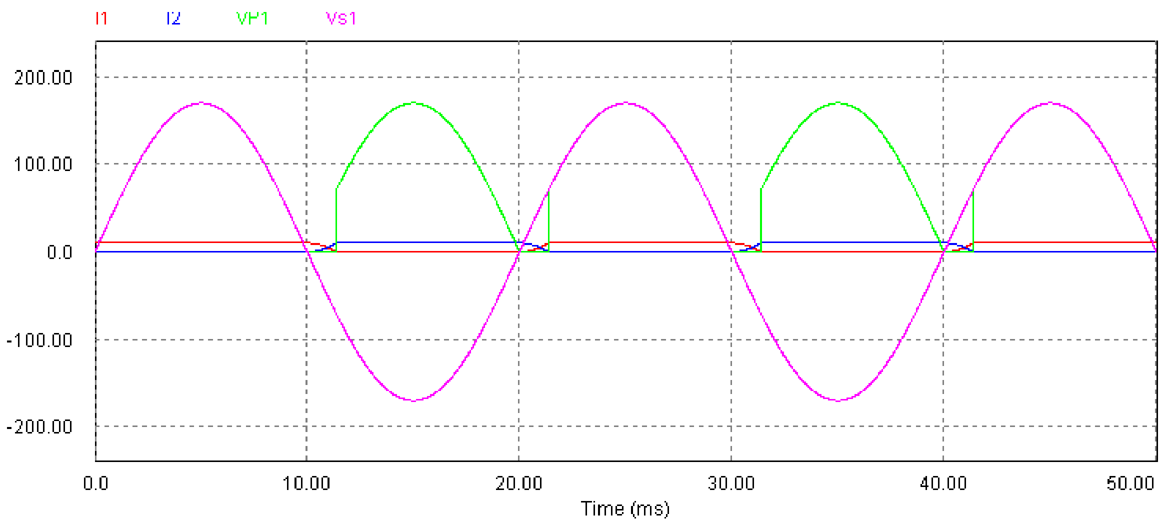
Circuits-

8) Basic concepts in thyristor converters.
9) 1-phase half-controlled bridge rectifier
10) 1-phase thyristor rectifier bridge
11) 1-phase thyristor inverters
12) Basic concepts in 3-phase thyristor converters
13) 3-phase thyristor rectifier bridge
14) 3-phase half-controlled bridge rectifier
15) 3-phase thyristor inverter

8) BASIC CONCEPTS IN THYRISTOR CONVERTERS:-

For given ac input voltages, the magnitude of the average output voltage in thyristor converters can be controlled by delaying the instants at which the thyristors are allowed to start conduction.

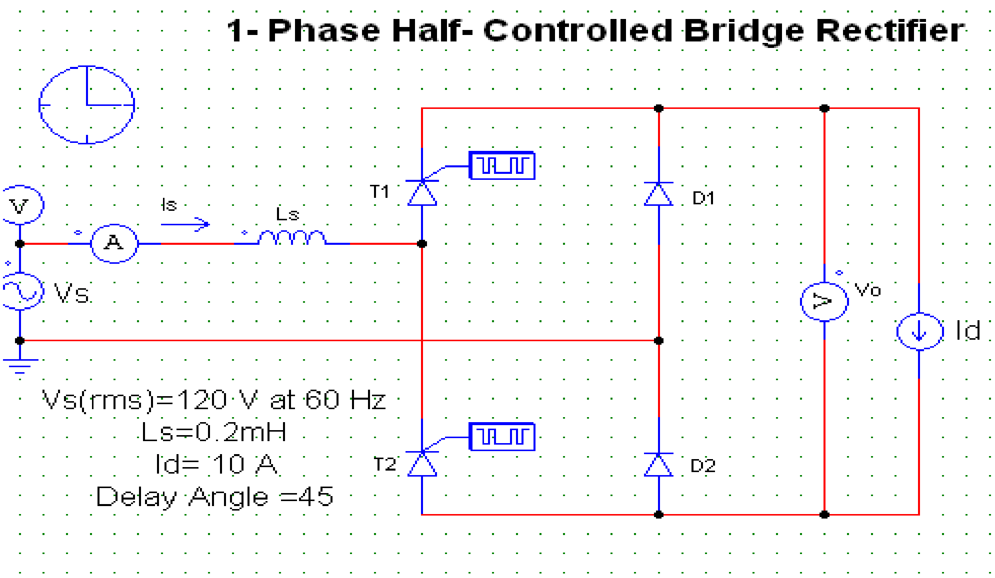




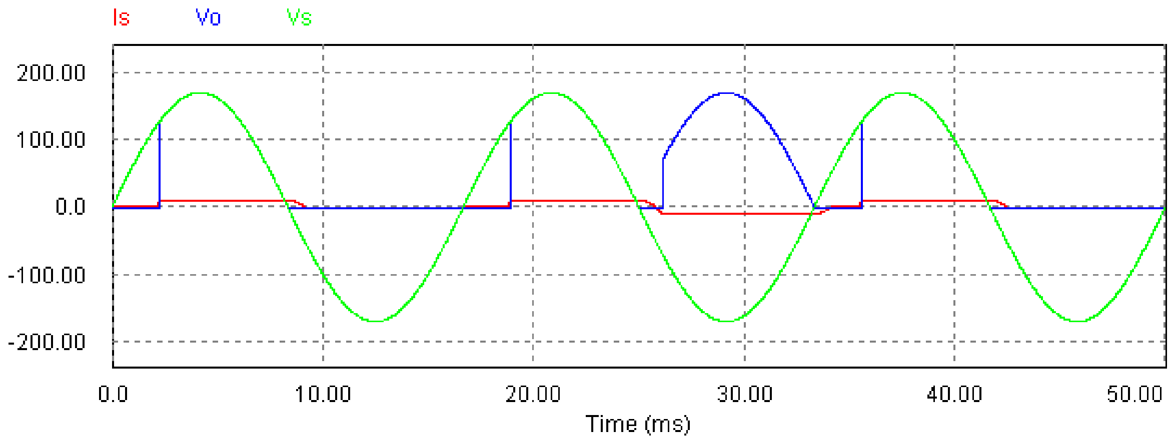
GRAPH-8

9) 1-PHASE HALF-CONTROLLED BRIDGE RECTIFIER:

A single-phase semi converter bridge consists of two diodes and two thyristors. The load is of RLE type. With T1 on, load gets connected to source through T1 and D1. For the period wt=45 to 180, load current flows through T1 and D1 and output Vo is of same wave shape as Vs. after wt=180 load voltage tends to reverse as ac voltage changes polarity. There is limited control over the level of dc output voltage.



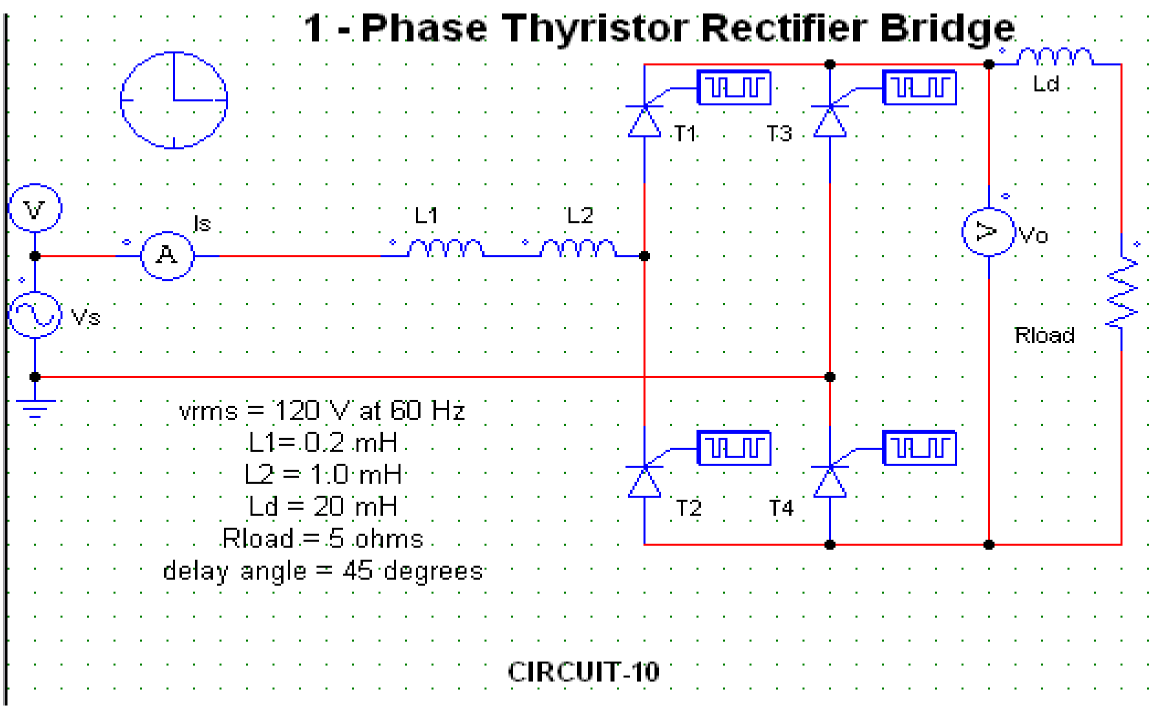
CIRCUIT-9



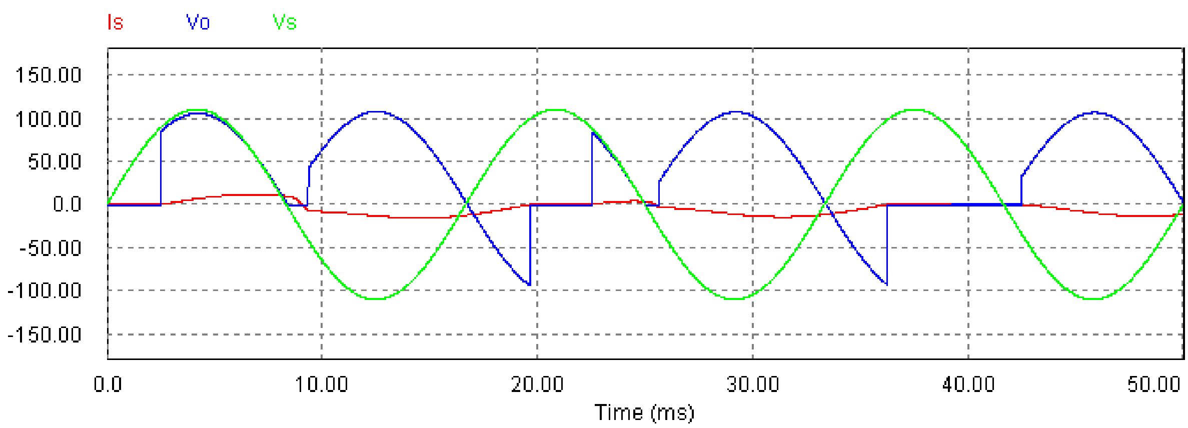
GRAPH-9

10) 1-PHASE THYRISTOR RECTIFIER BRIDGE:

A single phase full converter bridge consists of four SCRs as shown.Thyristor pair T1 and T2 is simultaneously triggered and 180 later, pair T3 and T4 is gated together. Voltage at the output terminals can be controlled by adjusting the firing angle delay of the thyristor. There is a wider control over the level of dc output voltage.



CIRCUIT-10



GRAPH-10

3.3 DC-to-DC Switch Mode converters:

The dc-dc converters are widely used in regulated switch mode dc power supplies and in dc motor drive applications. Often the input to these converters is an unregulated dc voltage, which is obtained by rectifying the line voltage. Switch mode dc-to-dc converters are used to convert the unregulated dc input into a controlled dc output at a desired voltage level.

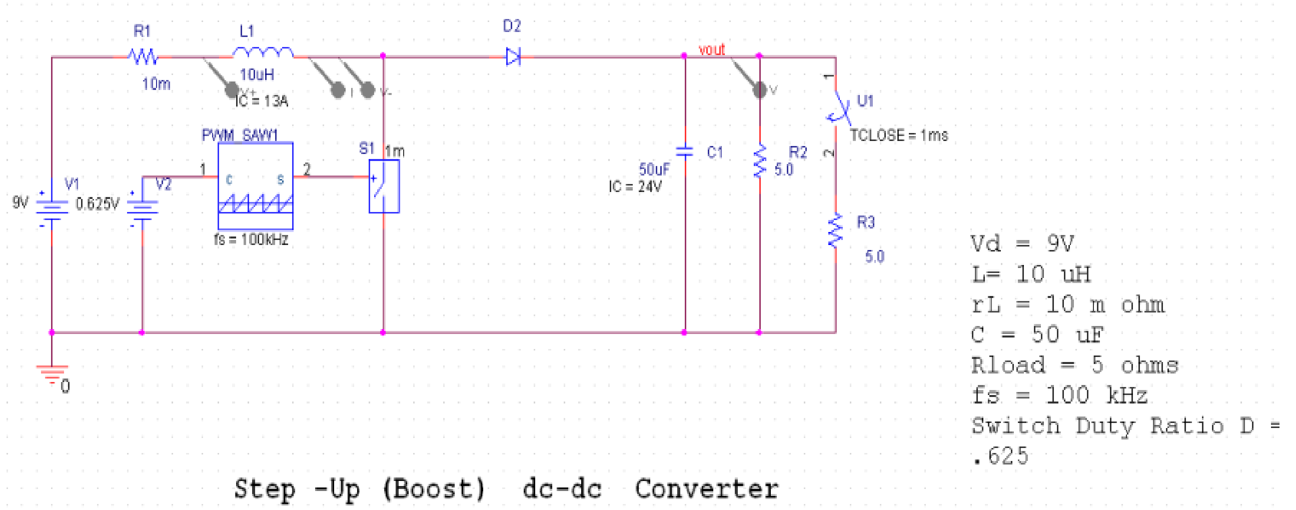
Switch mode dc-dc converters utilize one or more switches to transform dc from one level to another. The average output voltage is controlled by controlling the switch on-off durations.

Circuits-

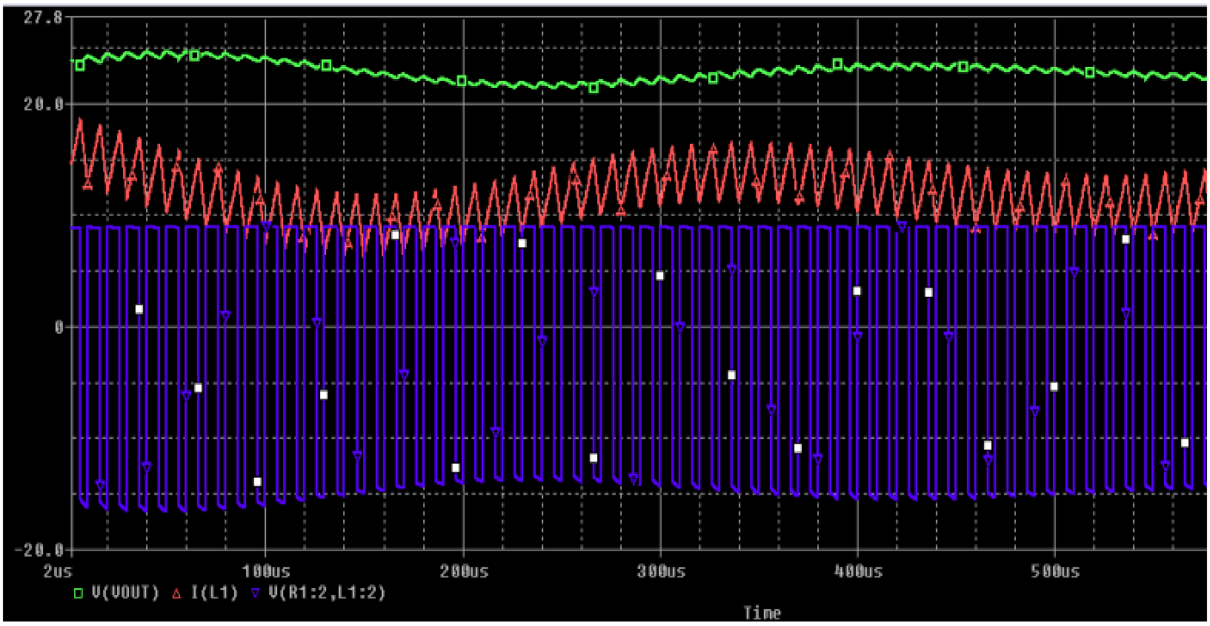
16) Step-up (Boost) dc-dc converter
17) Step-down (Buck) dc-dc converter using Average-Switch Model
18) Step-down /up (Buck/Boost) dc-dc converter Average-Switch Model
19) Full-Bridge, bipolar-voltage-switching dc-dc converter
20) Full-Bridge, unipolar-voltage-switching dc-dc converter

11) STEP-UP (BOOST) DC-DC CONVERTER:

Its main application is in regulated dc power supplies and the regenerative braking of dc motors. As the name implies, the output voltage is always greater than the input voltage. When the switch is on, the diode is reverse biased, thus isolating the output stage. The input supplies energy to the inductor. When the switch is off, the output stage receives energy from inductor as well as from the input.



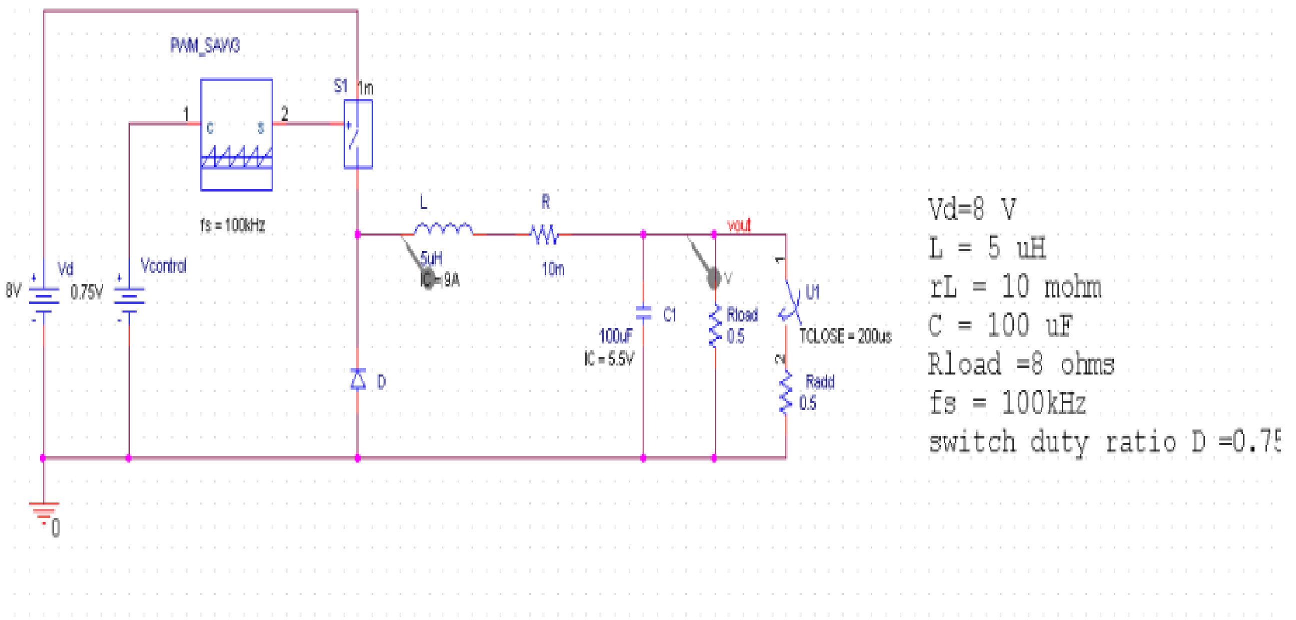
CIRCUIT-16



GRAPH-16

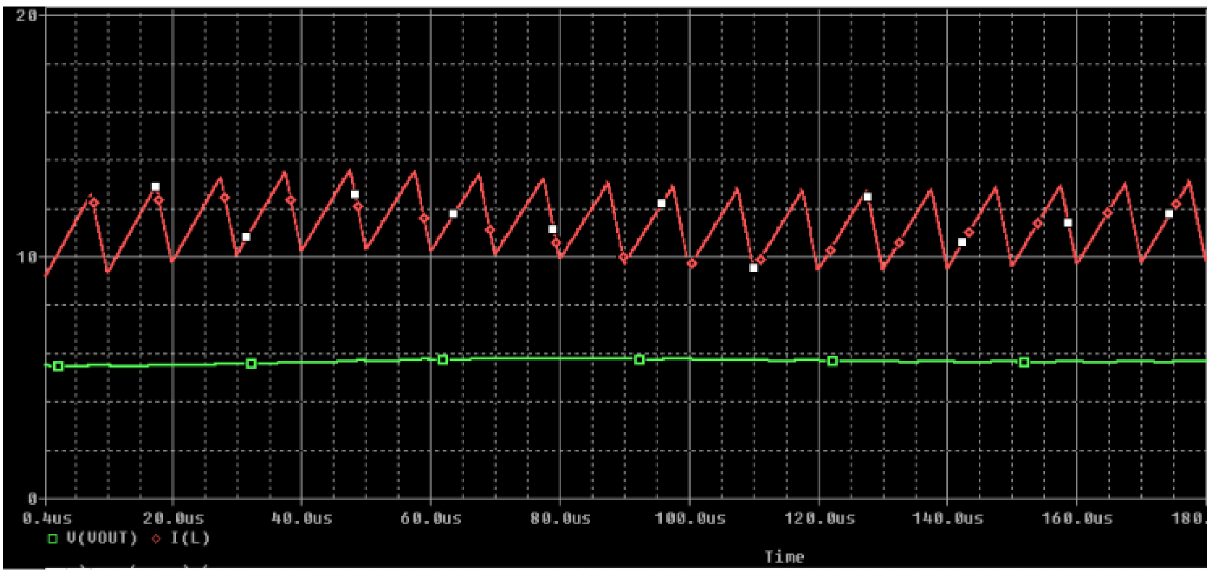
12) STEP-DOWN(BUCK) DC-DC CONVERTER USING AVERAGE SWITCH MODEL:

As the name suggests, a step down converter produces a lower average output voltage than the dc input voltage. Its main application is in regulated dc power supplies and dc speed motor control.



Step-Down (BUCK) dc-dc Converter using Averaged-Switch Model

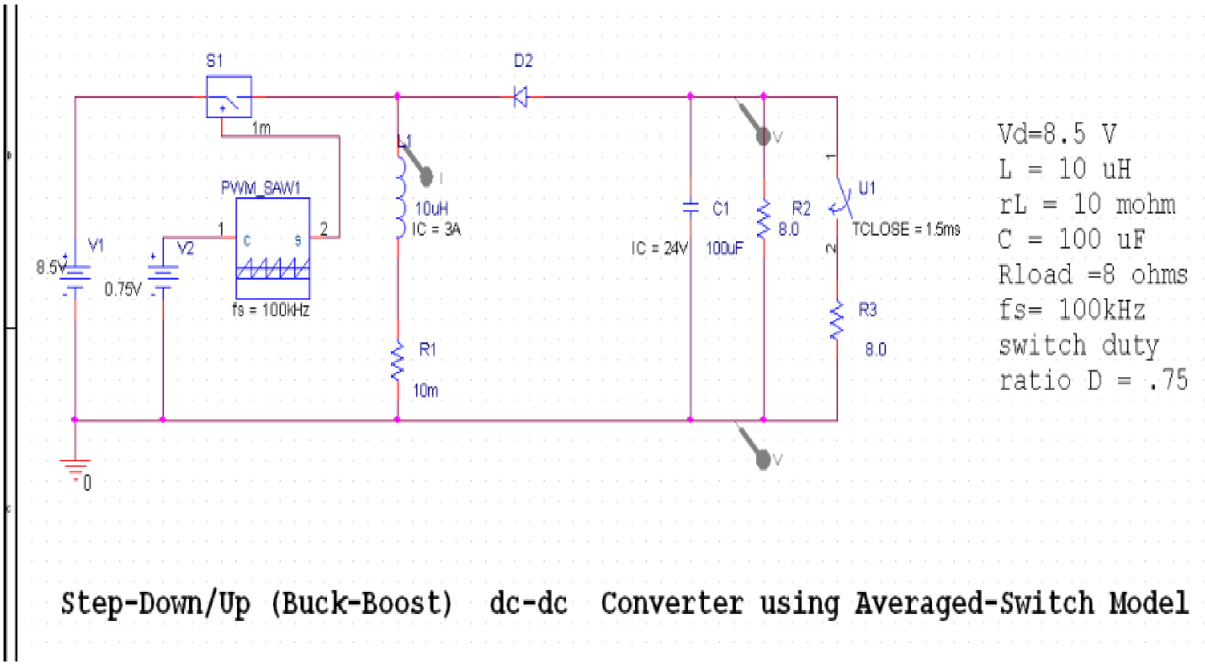
CIRCUIT-17



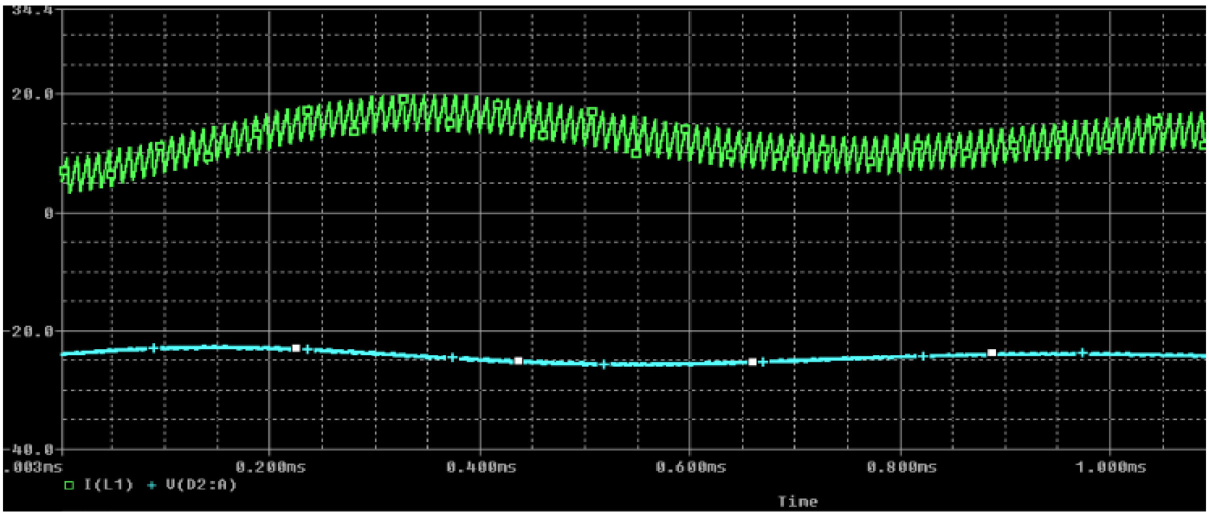
GRAPH-17

13) STEP-DOWN/UP (BUCK/BOOST) DC-DC CONVERTER USING AVERAGE SWITCH MODEL:

A buck-boost converter can be obtained by the cascade connection of two basic converters, the step down and the step-up converter. The main application of this converter is in regulated dc power supplies where a negative output may be desired with respect to common terminal of the input voltage. The output voltage can be greater than or less than the input voltage.



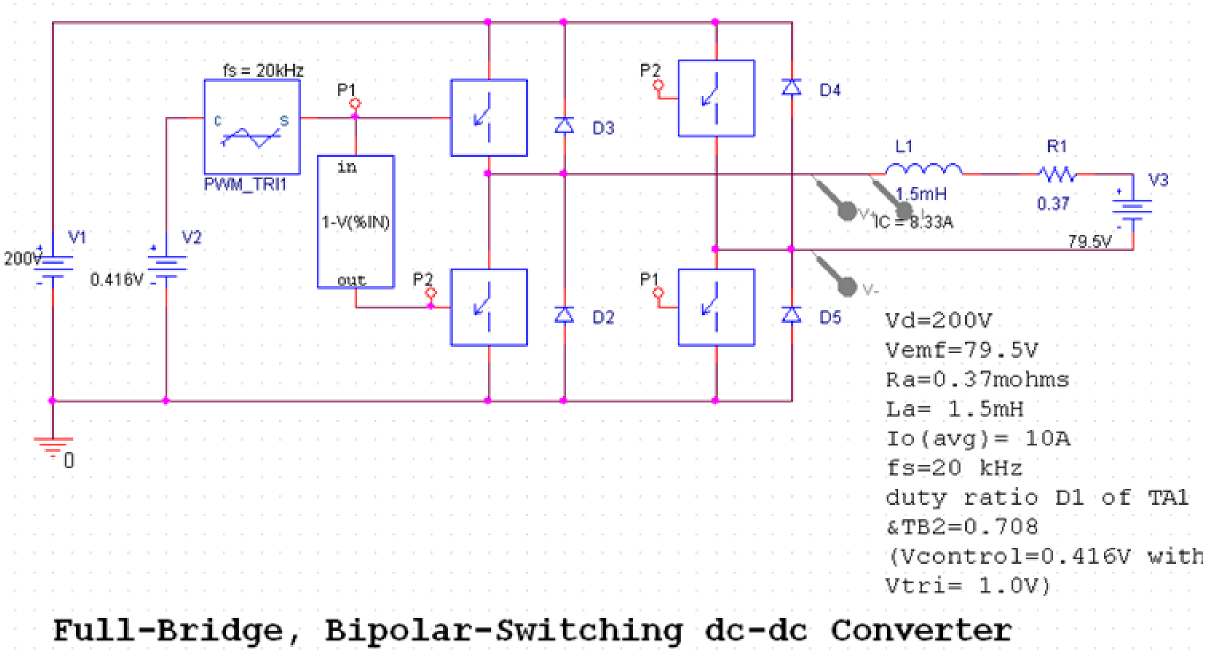
CIRCUIT-18



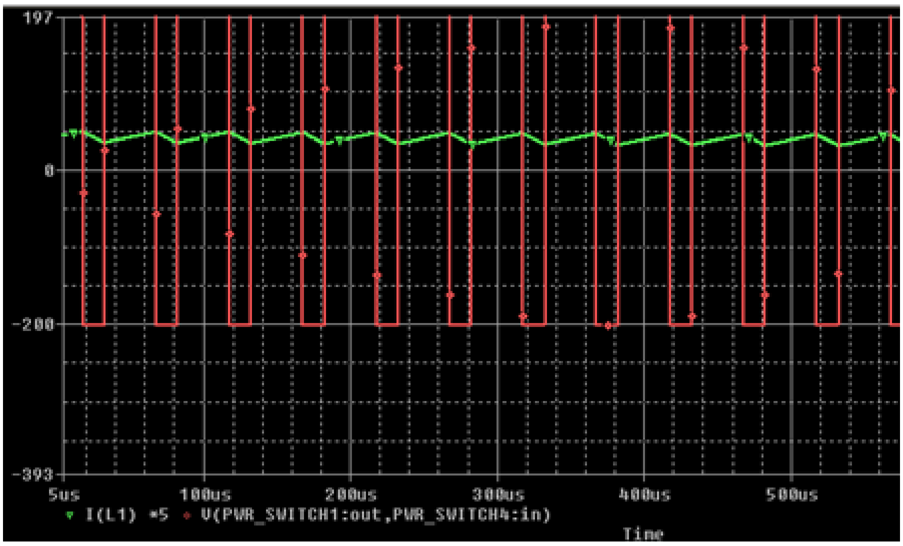
GRAPH-18

14) FULL-BRIDGE,BIPOLAR-SWITCHING DC-DC CONVERTER:

PWM with bipolar voltage switching, where (T_{A+},T_{B-}) and (T_{A-},T_{B+}) are treated as two switch pairs; switches in each pair are turned on and off simultaneously. One of the two pairs is always on. The switching signals are generated by comparing a switching-frequency triangular waveform with the control voltage.



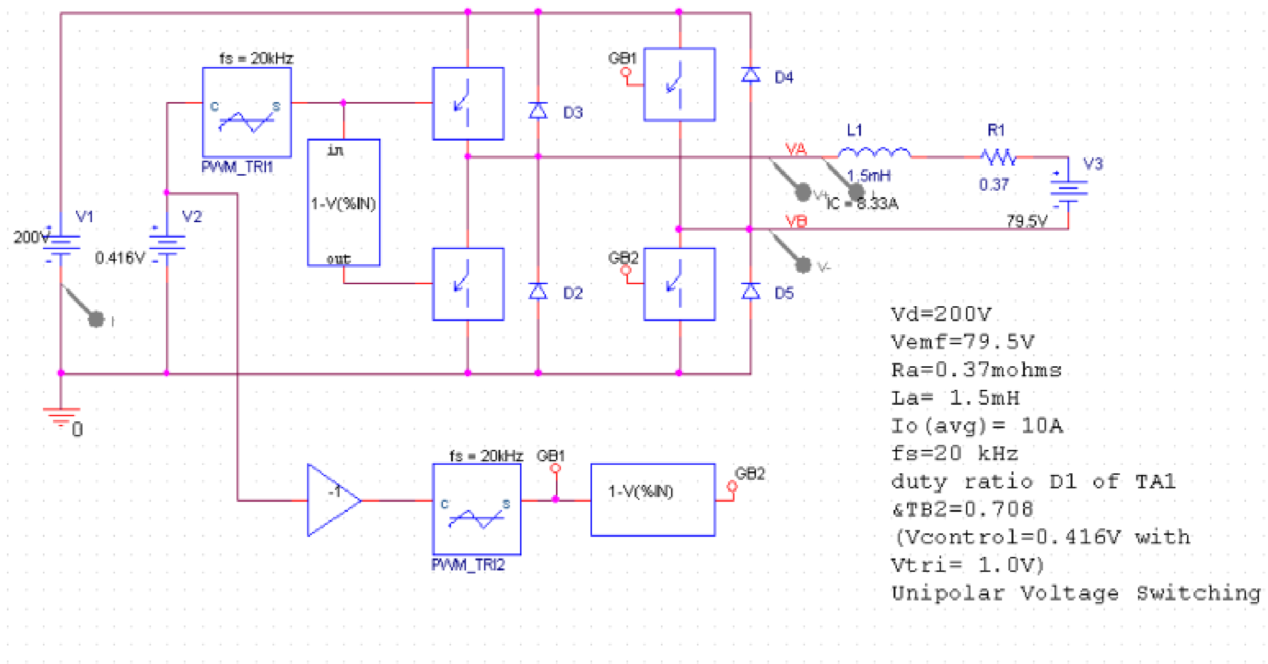
CIRCUIT-19



GRAPH-19

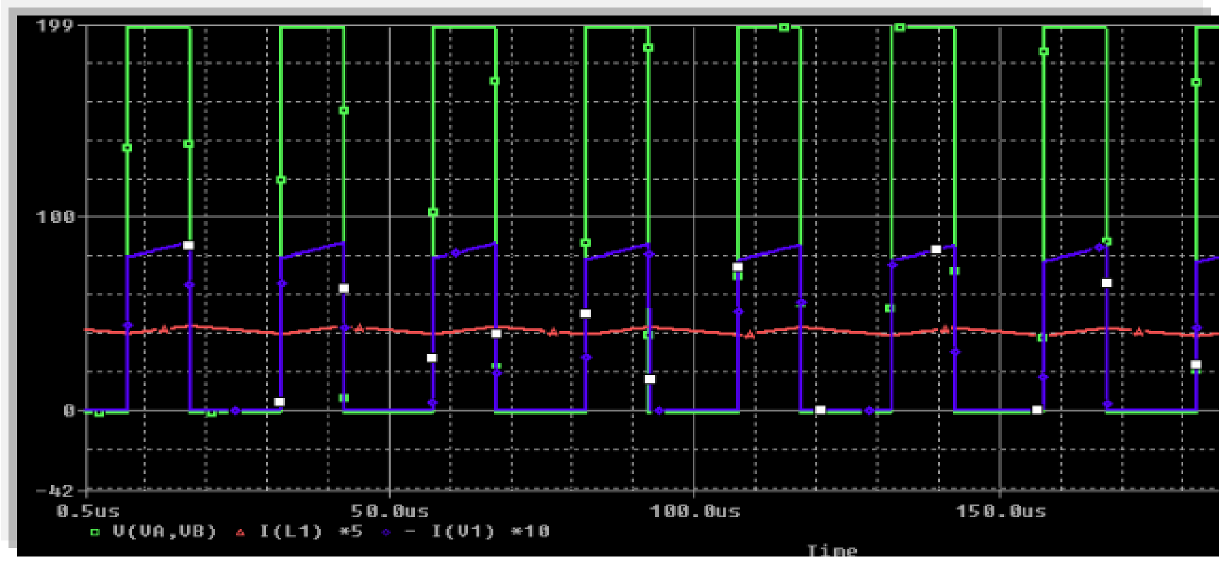
15) FULL-BRIDGE,UNIPOLAR SWITCHING DC-DC CONVERTER:

PWM with unipolar voltage switching is also referred to as the double PWM switching. Here the switches in each inverter leg are controlled independently of the other leg. Regardless of the direction of the Io, Vo=0 if T_{A+} and T_{B+} are both on or if both T_{A-} and T_{B-} are both on.



Full-Bridge, Unipolar Switching dc-dc Converter

CIRCUIT-20



GRAPH-20

3.4 Switch-Mode DC-to-Sinusoidal Inverters:

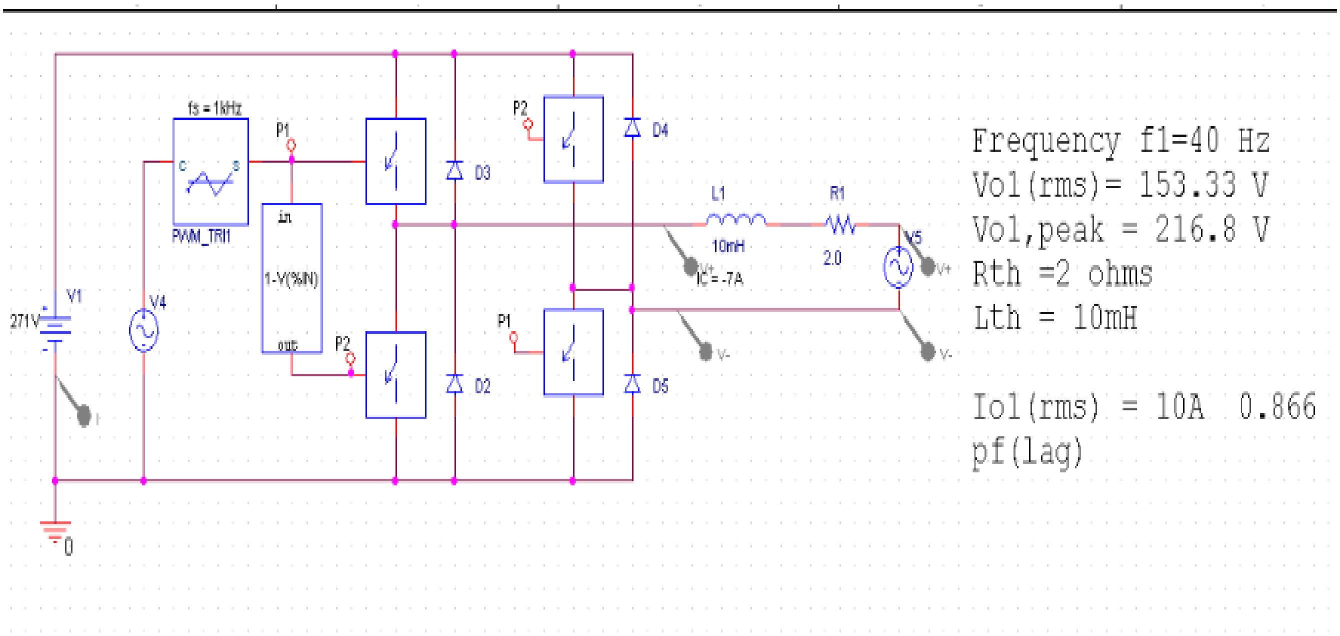
Switch mode dc-to-ac inverters are used in ac motor drives and uninterruptible ac power supplies where the objective is to produce a sinusoidal ac output whose magnitude and frequency can both be controlled. The input to switch mode inverters will be assumed to be a dc source. Such inverters are referred to as voltage source inverters (VSIs).

Circuits-

21) PWM, bipolar-voltage-switching, 1-phase.
22) PWM, unipolar-voltage-switching, 1-phase
23) Square Wave, 1-phase
24) Voltage-Cancellation Control, 1-phase
25) PWM Inverter, 3-phase

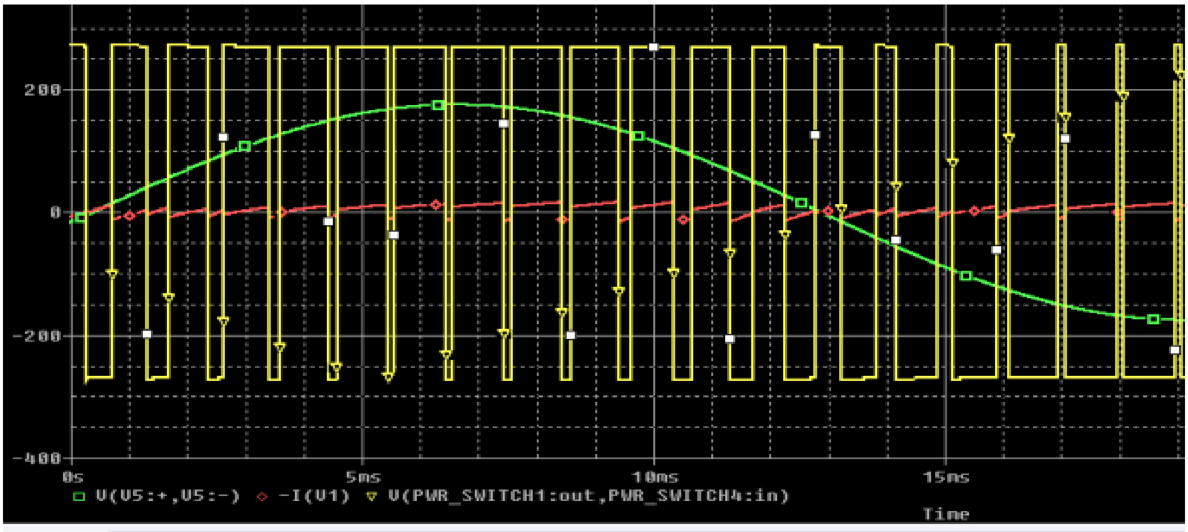
16) 1-PHASE, BIPOLAR-VOLTAGE SWITCHING INVERTER:

PWM with bipolar voltage switching, where (T_{A+},T_{B-}) and (T_{A-},T_{B+}) are treated as two switch pairs; switches in each pair are turned on and off simultaneously. One of the two pairs is always on. The switching signals are generated by comparing a switching-frequency triangular waveform with the control voltage.



1-Phase, Bipolar- Voltage Switching Inverter

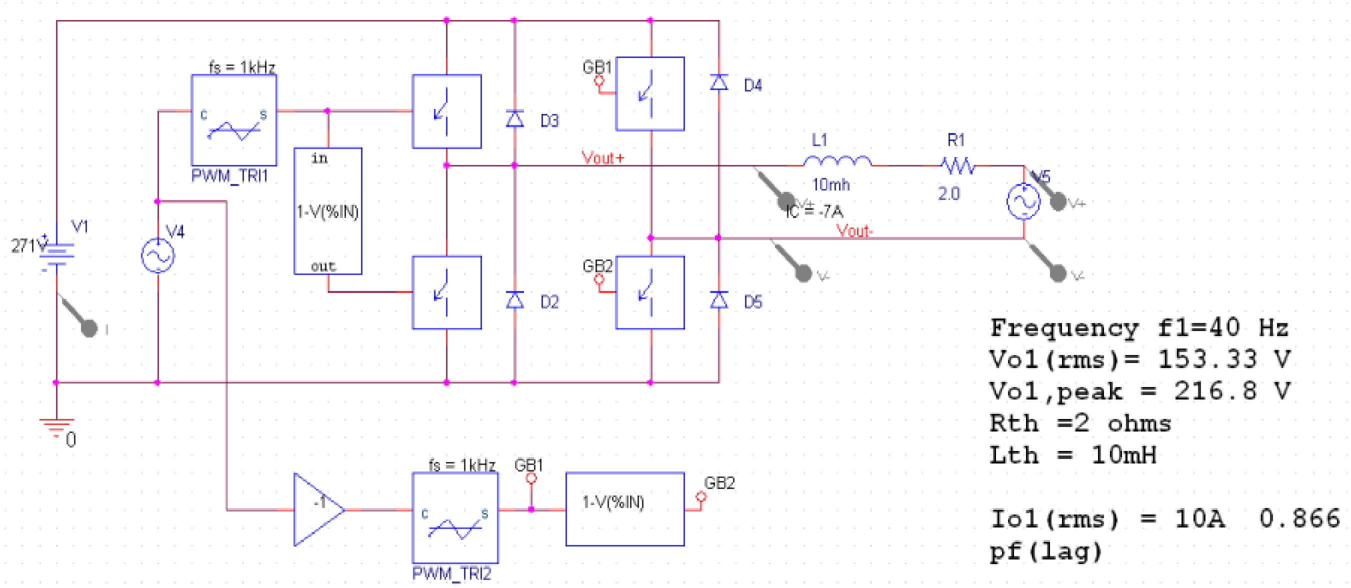
CIRCUIT-21



GRAPH-21

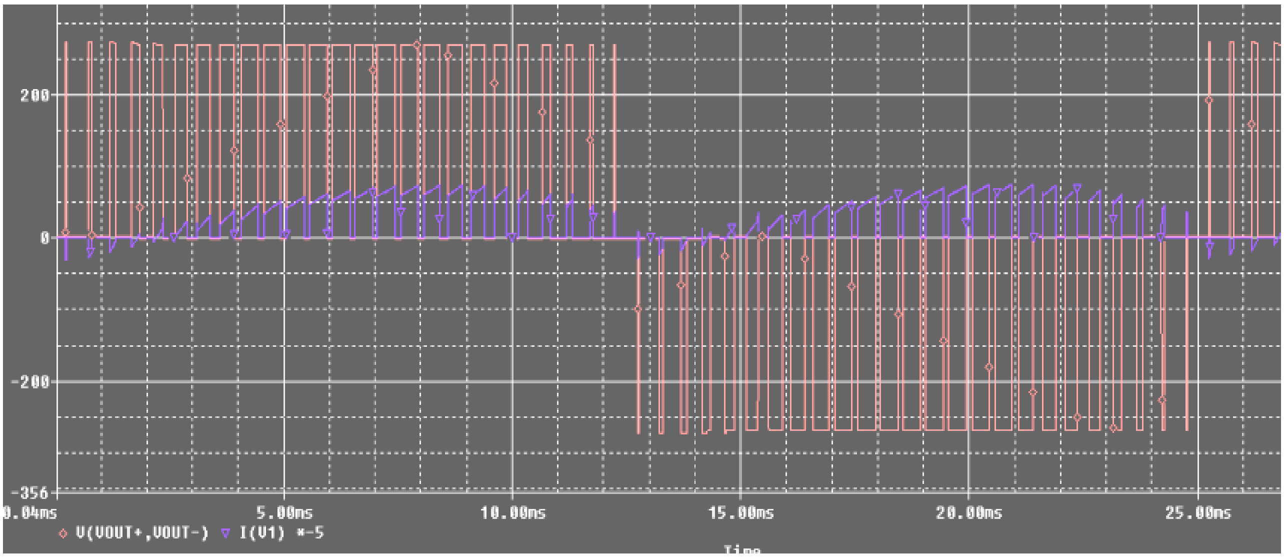
17) 1-PHASE UNIPOLAR-VOLTAGE SWITCHING INVERTER:

PWM with unipolar voltage switching is also referred to as the double PWM switching. Here the switches in each inverter leg are controlled independently of the other leg. Regardless of the direction of the Io, Vo=0 if T_{A+} and T_{B+} are both on or if both T_{A-} and T_{B-} are both on.



1-Phase Unipolar-Voltage Switching Inverter

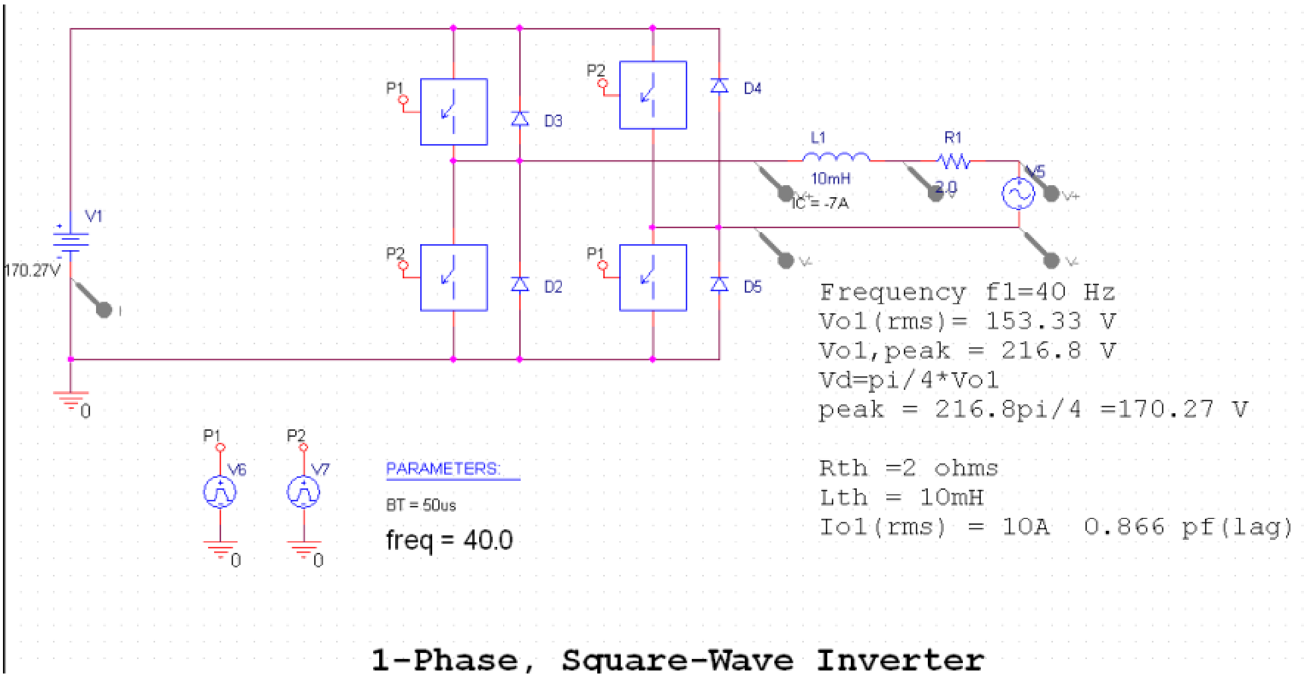
CIRCUIT-22



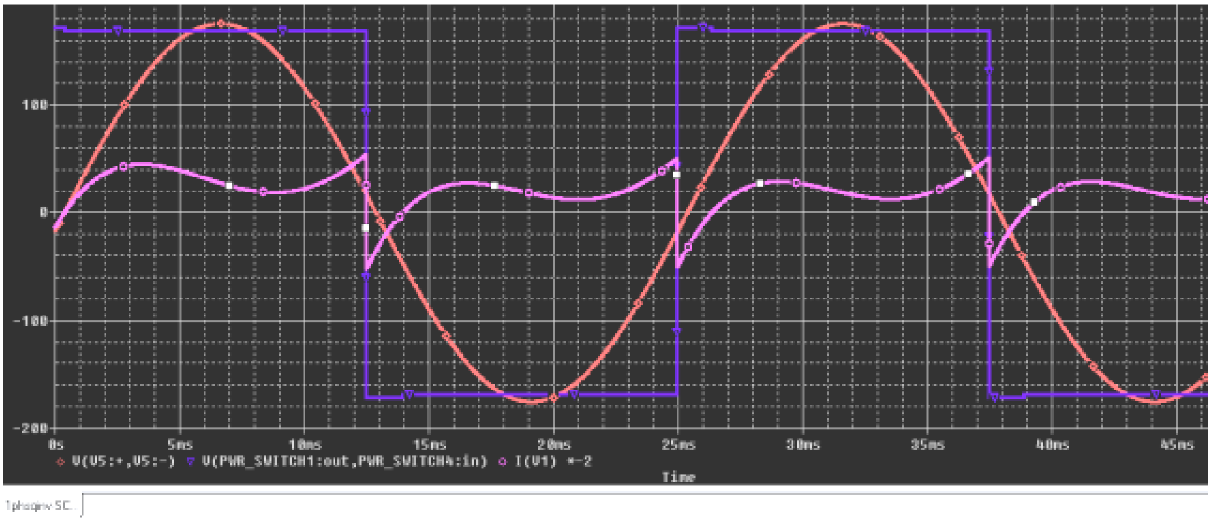
GRAPH-22

18) 1-PHASE, SQUARE WAVE INVERTER:

In these inverters, the input dc voltage is controlled in to control the magnitude of the output ac voltage, and therefore the inverter has to control only the frequency of the output voltage. The output ac voltage has a waveform similar to a square wave, and hence these inverters are called square wave inverters.



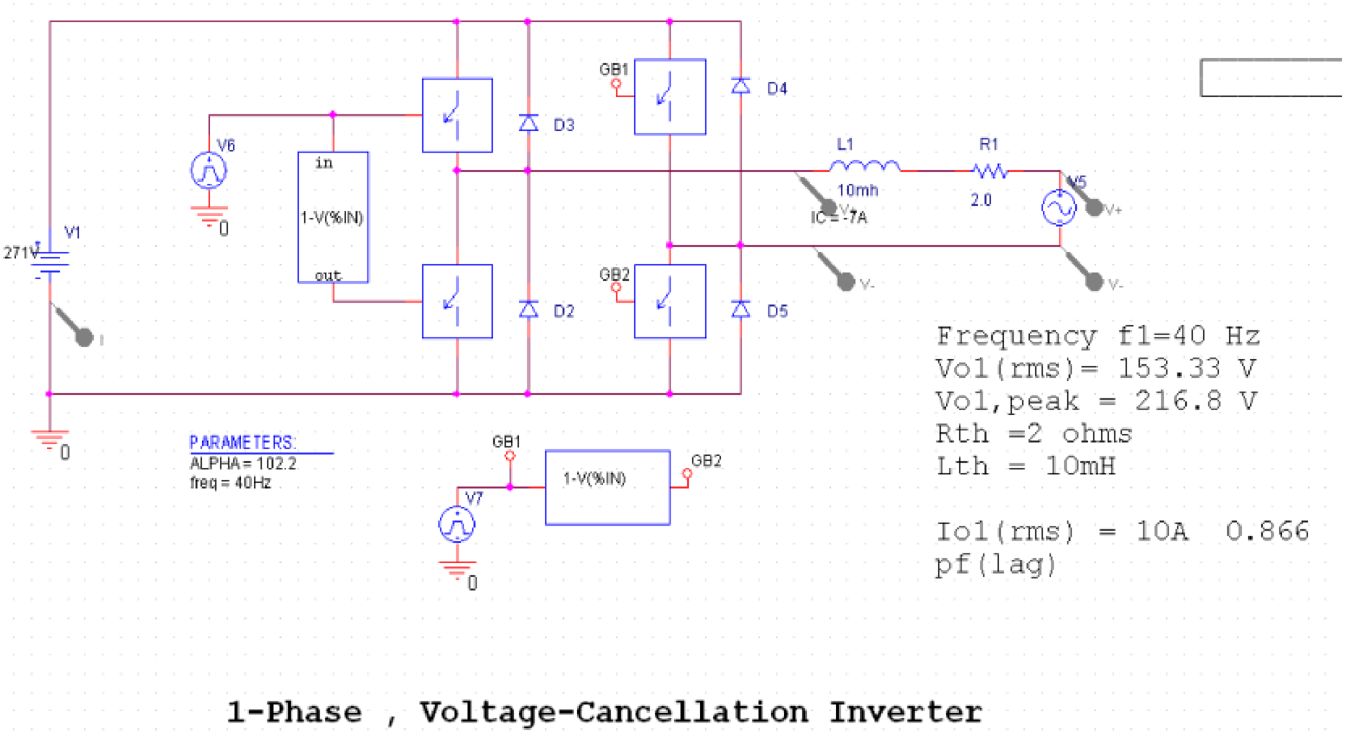
CIRCUIT-23



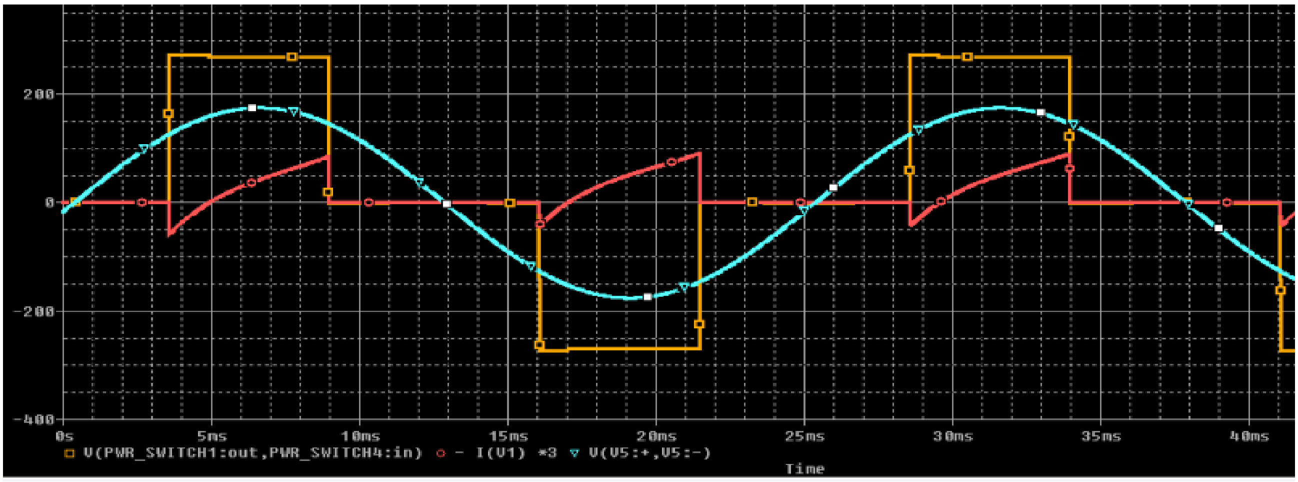
GRAPH-23

19) 1-PHASE VOLTAGE CANCELLATION INVERTER:

In case of inverters with single phase output, it is possible to control the magnitude and the frequency of the inverter output voltage, even though the input to the inverter is a constant dc voltage and the inverter switches are not pulse width modulated. It is to be remembered that the voltage cancellation techniques work only with single phase inverters and not with three phase inverters.

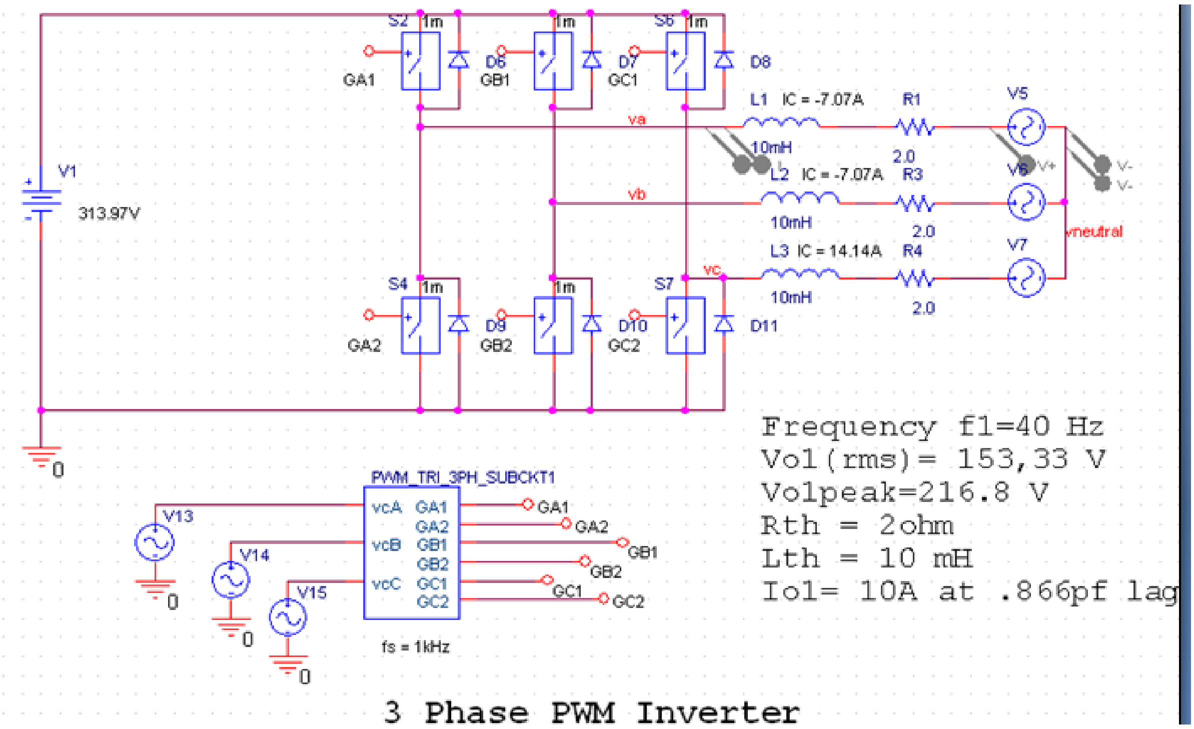


CIRCUIT-24



GRAPH-24

20) 3-PHASE PWM INVERTER:



CIRCUIT-25

GRAPH-25

3.5 Resonant Converters: Zero Voltage/Current Switching:

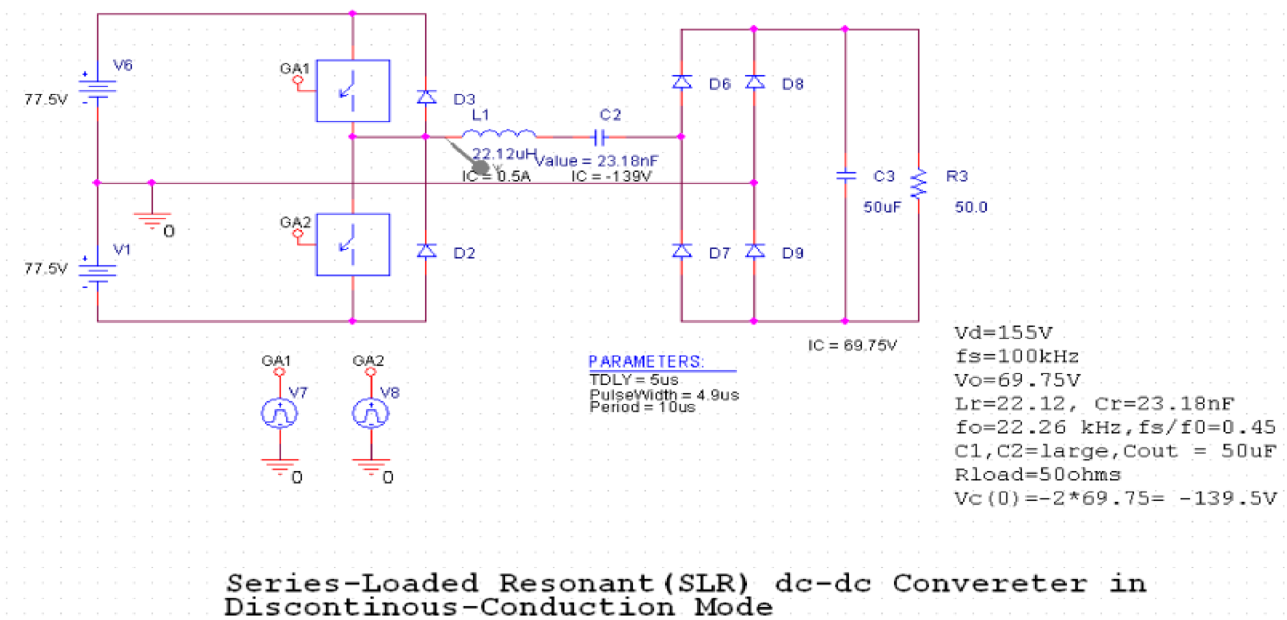
in all the pulse width modulated dc-to-dc and dc-to ac converter, the controllable switches are operated in a switch mode where they are required to turn on and turn off the entire load current during each switching. In such operation the switches are subjected to high switching stresses and high switching power loss. If each switch in a converter changes its status from on to off or vice versa when the voltage across it is zero at the switching instant, then the above mentioned shortcomings can be minimised. The converter topologies which result in zero voltage and zero current switching require some form of LC resonance so they are known as “resonant converters”.

Circuits-

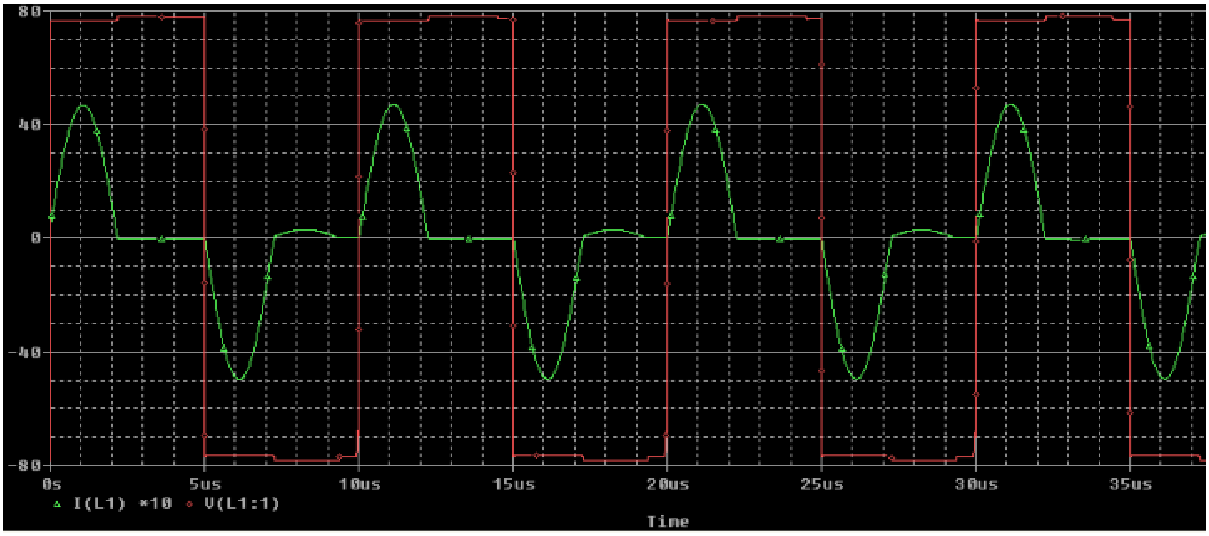
26) Series loaded Resonant converters, Discontinuous conduction mode.
27) Parallel loaded Resonant DC-DC converter operating above resonant frequency.
28) Zero Current Switching, Quasi Resonant Buck Converter.
29) Zero Voltage Switching, Clamped Voltage Converter.

26) SERIES LOADED RESONANT (SLR) DC-DC CONVERTER IN DISCONTINUOUS MODE:

In this mode of operation, the switches turn off naturally at zero current and at zero voltage, since the inductor current goes through zero. The switches turn on at zero current but not at zero voltage. Also the diode turns on at zero current and turn off naturally at zero current. The disadvantage of this mode is relatively large peak current in the circuit, so higher conduction losses.



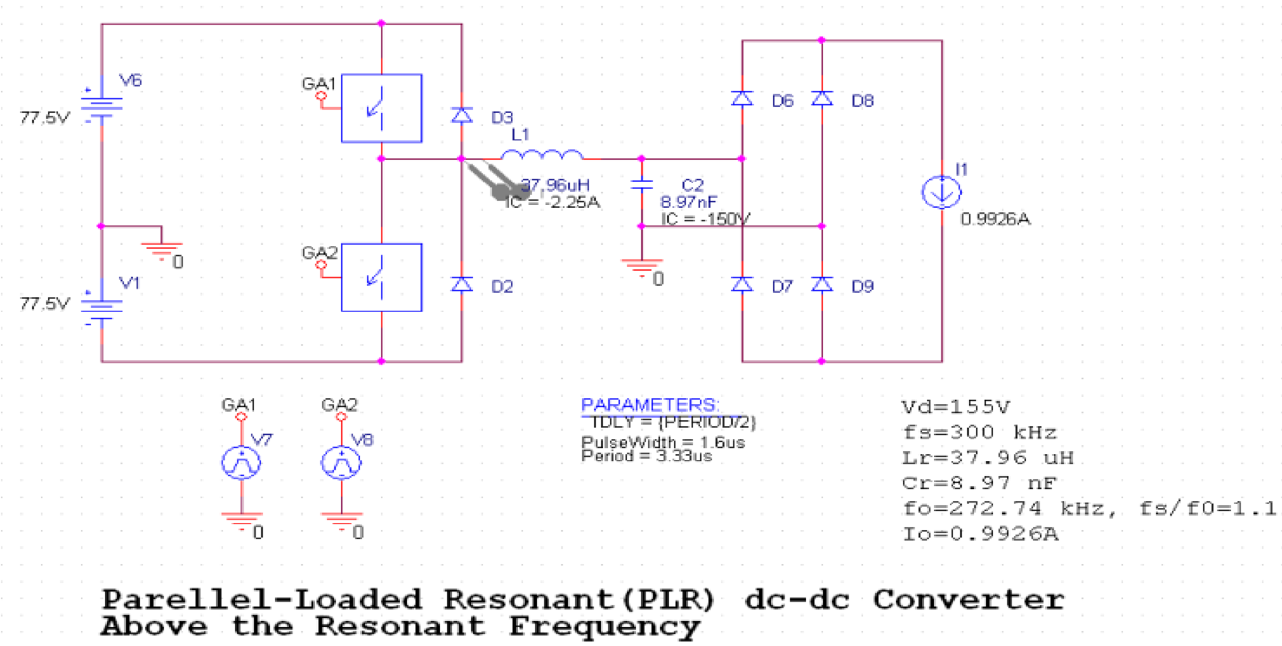
CIRCUIT-26



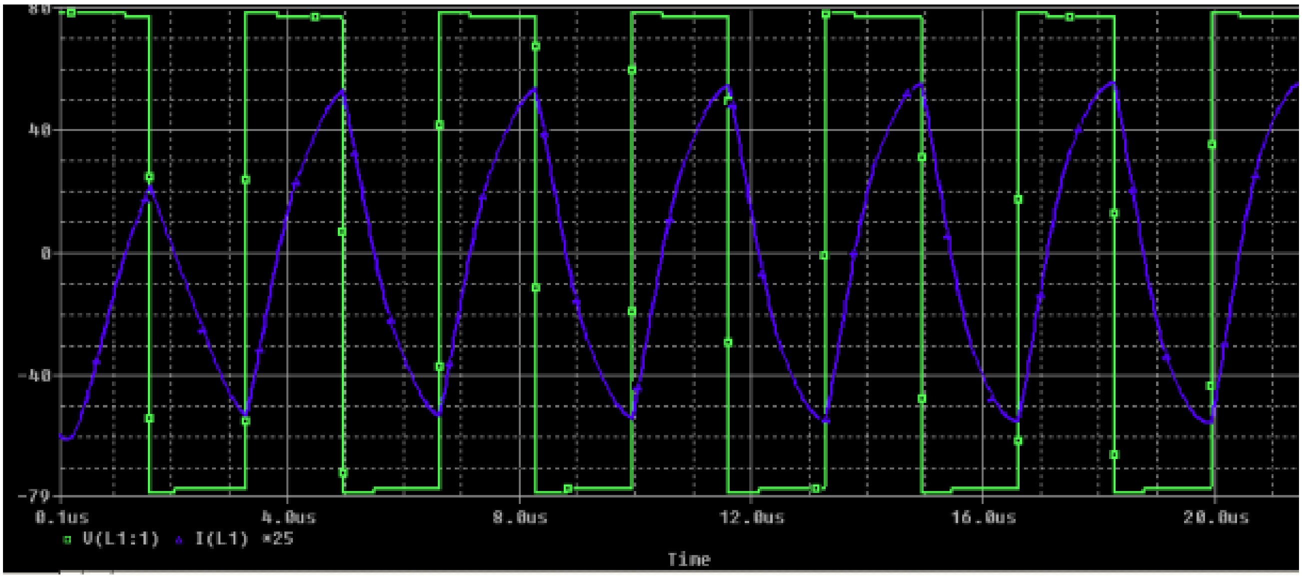
GRAPH-26

27)PARALLEL LOADED RESONANT DC-DC CONVERTER ABOVE RESONANT FREQUENCY:

PLR converters appear as a voltage source and are better suited for multiple outlets. They dont possess inherent short-circuit protection capability. These converters can step-up as well as step down the voltage.



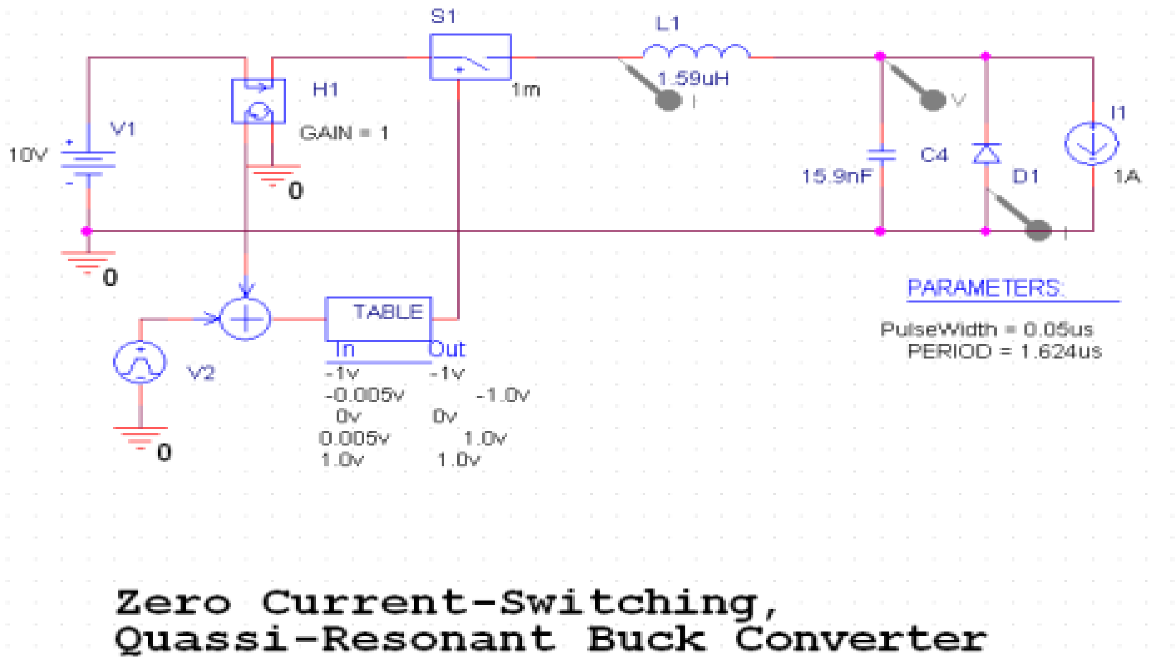
CIRCUIT-27



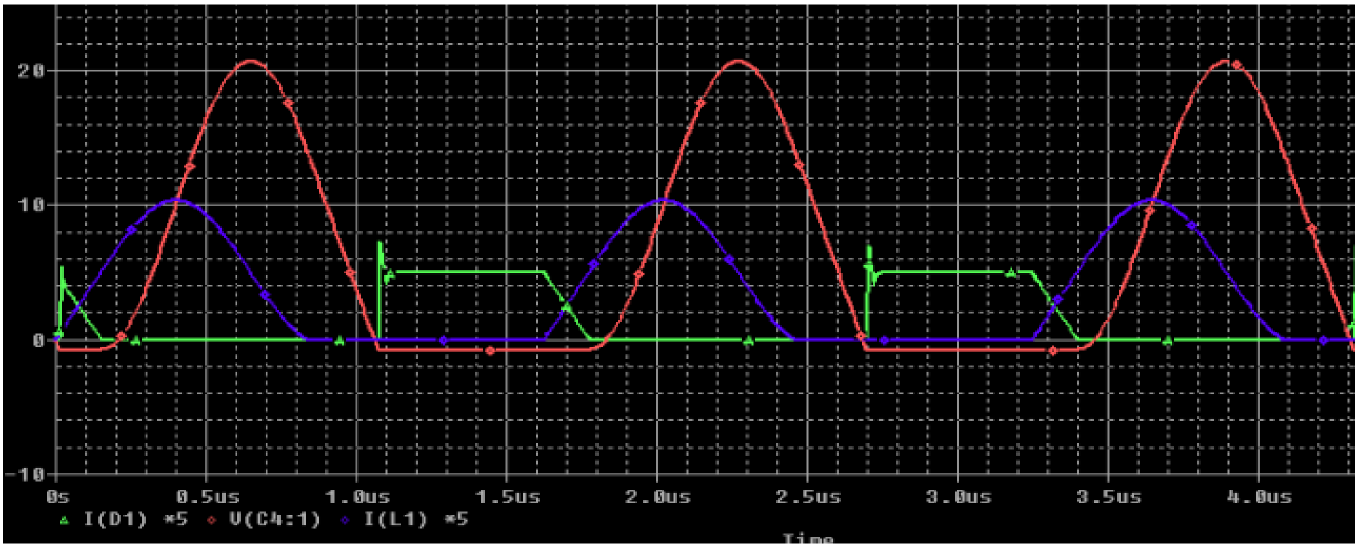
GRAPH-27

28) ZERO CURRENT SWITCHING, QUASSI RESONANT BUCK CONVERTER:

In such converters, the current produced by LC resonance flows through the switch, thus causing it to turn on and off at zero current. The peak switch voltage remains the same. One drawback of such a converter is that the switch peak current rating required is significantly higher than the load current. Moreover, the conduction losses would also be higher.



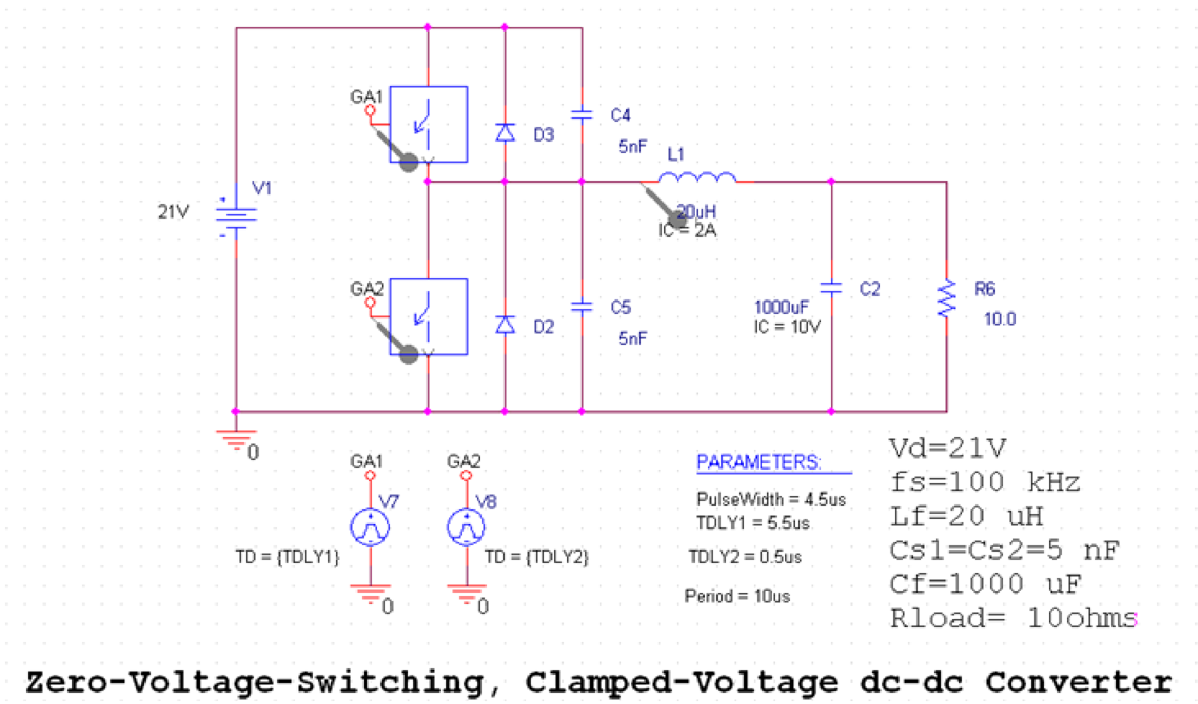
CIRCUIT-28



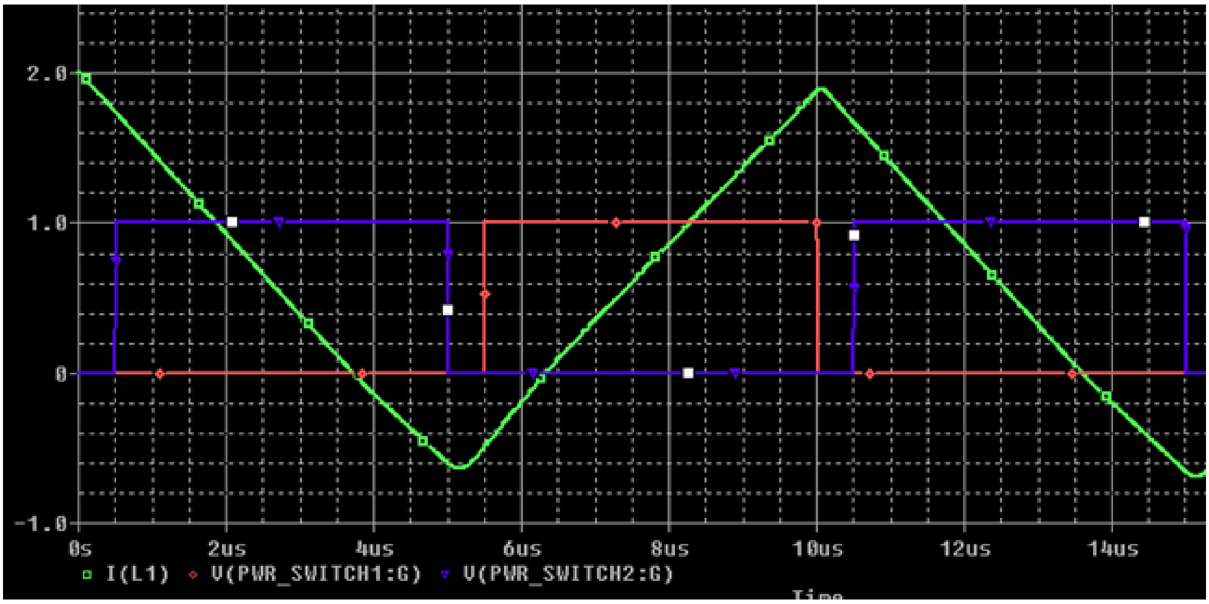
GRAPH-28

29) ZERO VOLTAGE SWITCHING, CLAMPED VOLTAGE DC-DC CONVERTER:

Here the switch turns on and off at zero voltage.. In this converter, at least one converter leg is made up of two such switches. The peak switch voltage remains the same as in its switch mode counterpart, but the peak switch current is generally higher.



CIRCUIT-29



GRAPH-29

3.6 Switch-Mode DC power Supplies with Isolation:

Regulated dc power supplies are needed for most analog and digital electronic systems. Advances in the semiconductor technology have led to switching power supplies, which are smaller and much more efficient than the linear power supplies. In switching power supplies, the transformation of dc voltage from one-level to another is accomplished by using dc-to dc converter circuits. These circuits employ solid-state devices which operate as a switch.

In a switching supply with electrical isolation the input ac voltage is rectified into an unregulated dc voltage by means of a diode rectifier.

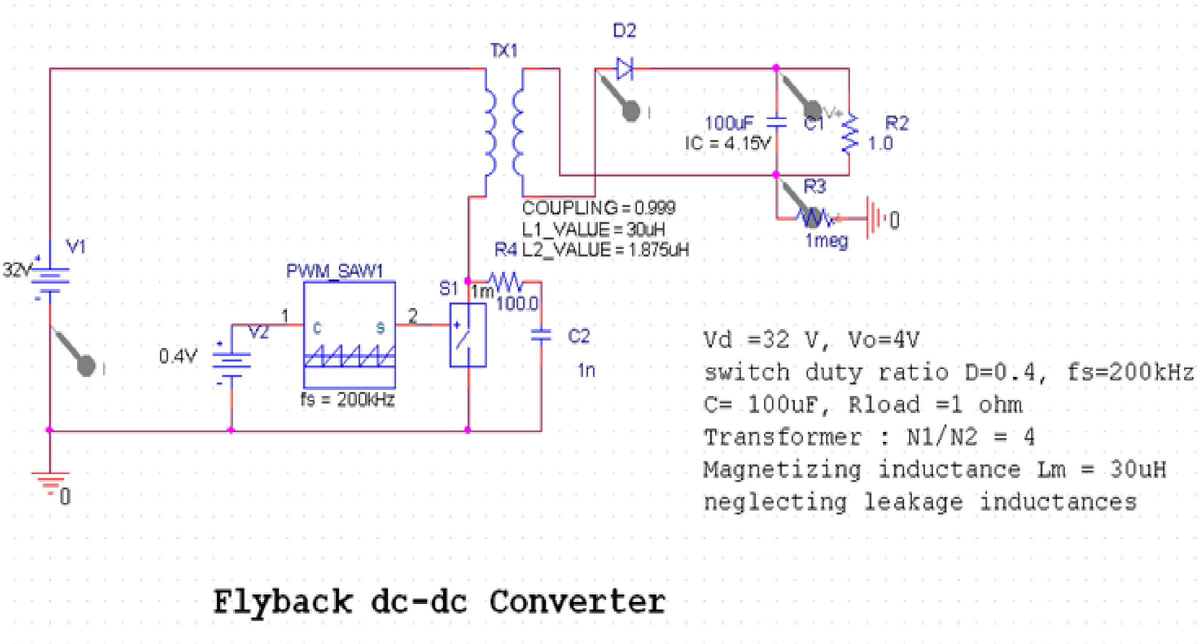
Circuits-

30) Flyback DC-DC Converters.
31) Forward Converters.

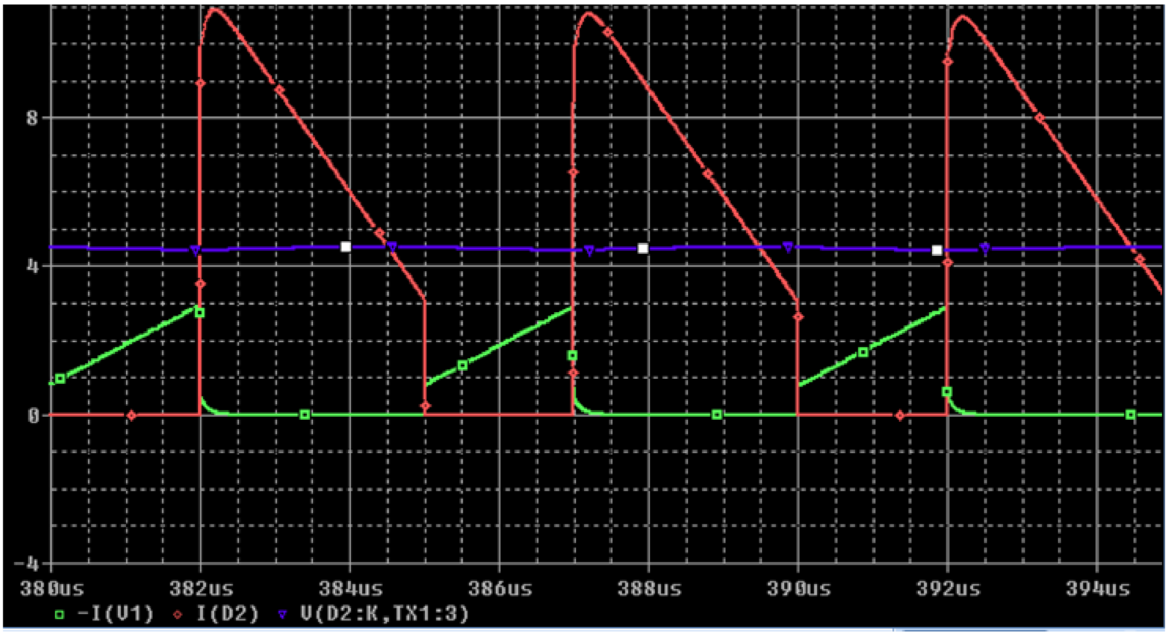
30) FLYBACK DC-DC CONVERTER:

Flyback converters are derived from buck boost converter. By placing a second winding on the inductor, it is possible to achieve electrical isolation.

In the circuit given below, when the switch is on, due to winding polarities, the diode D becomes reverse biased. The continuous current conduction mode in buck-boost converter corresponds to the incomplete demagnetisation of the inductor core in the flyback converter. Therefore, the inductor core flux increases linearly.



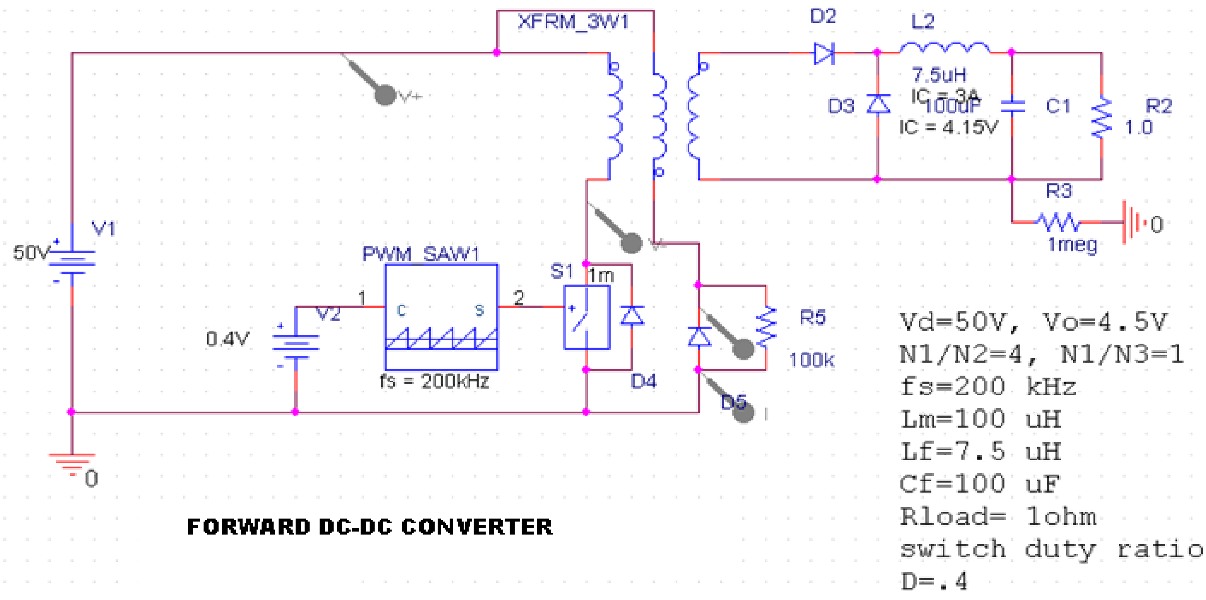
CIRCUIT-30



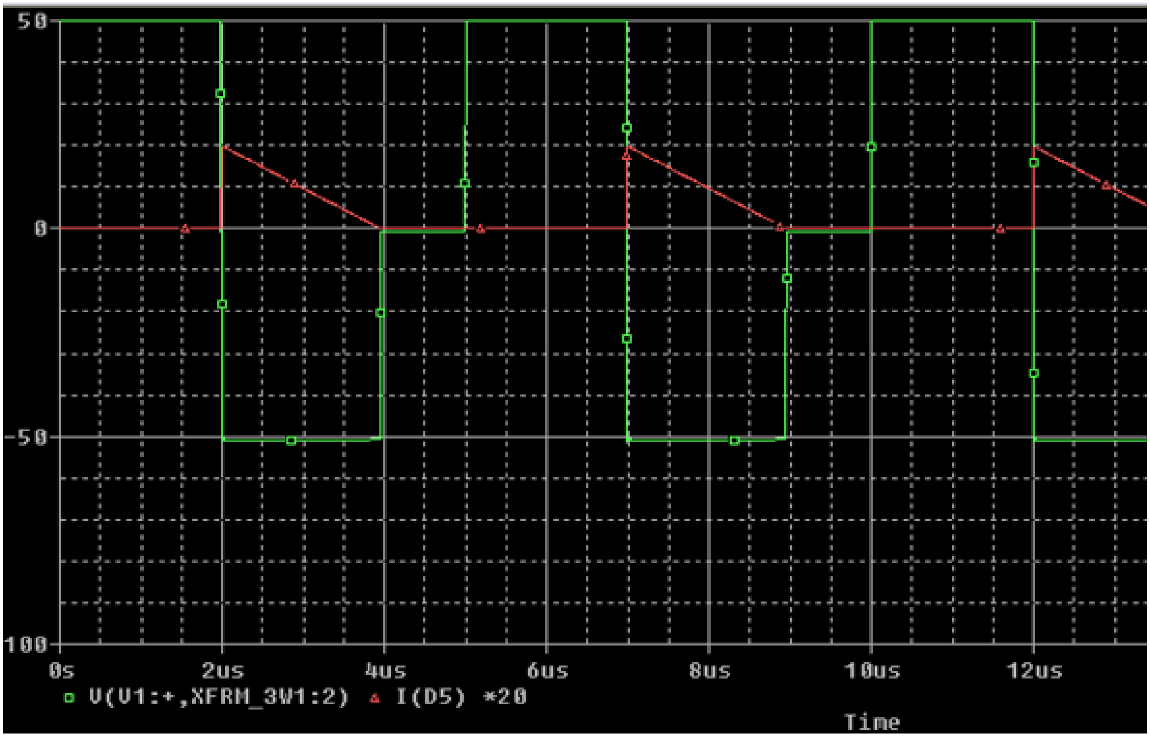
GRAPH-30

31) FORWARD DC-DC CONVERTER:

Initially assuming a transformer to be ideal, when the switch is on, D1 becomes forward biased and D2 reverse biased. Therefore current increases. When the switch is off, the inductor current circulates through diode D2 and current decreases linearly.



CIRCUIT-31



GRAPH-31

3.7 Motor Drives:

Motor-drives are used in a very wide power range, from a few watts to many thousand of kilowatts, in applications ranging from very precise, high performance position controlled drives in robotics to variable speed drives for adjusting flow rates in pumps. In all drives where the speed and the position are controlled, a power electronic converter is needed as an interface between the input power and the motor.

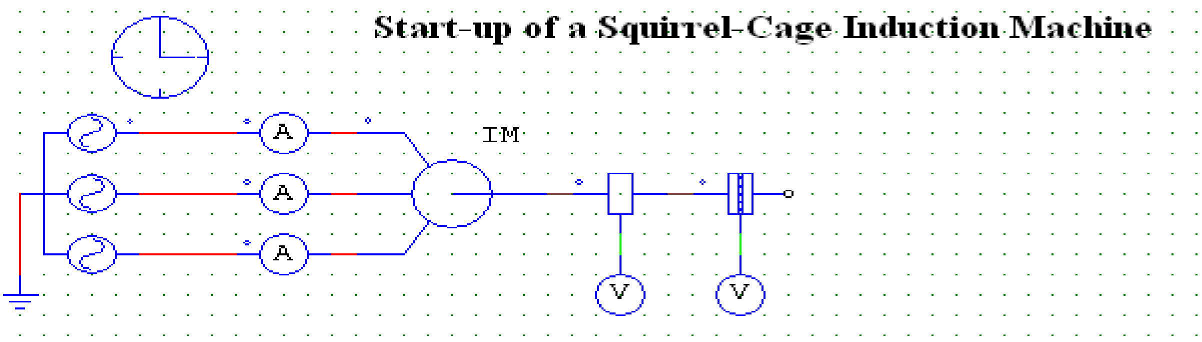
A motor drive basically consists of an electric motor, a power electronic converter, and possibly a speed and/or position sensor.

Circuits-

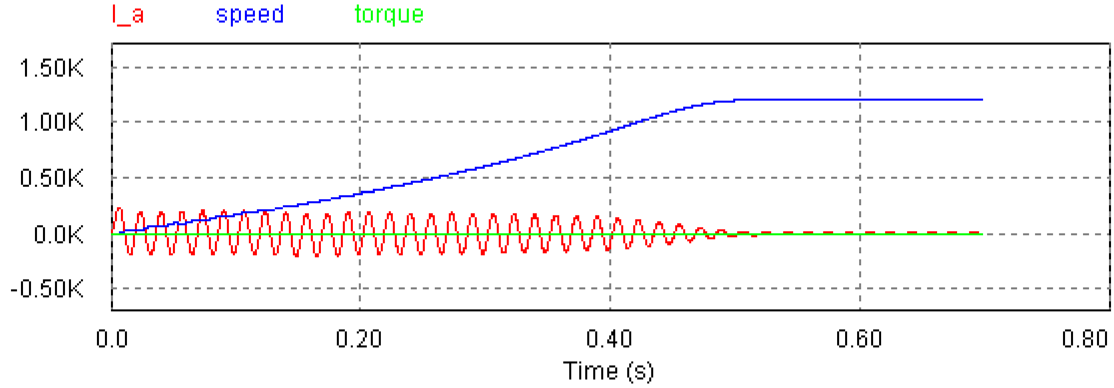
32) Start up of a Squirrel Cage Induction Machine.
33) Induction Motor with Constant-Power Load.
34) Induction Motor with Constant Torque Load.

32) START-UP OF A SQUIRREL CAGE INDUCTION MACHINE:

Induction motors with squirrel cage rotors are the workhorse of industry because of their low cost and rugged construction. When operated directly from the line voltages, an induction motor operates at a nearly constant speed. However, by means of power electronic converters, it is possible to vary the speed of an induction motor.



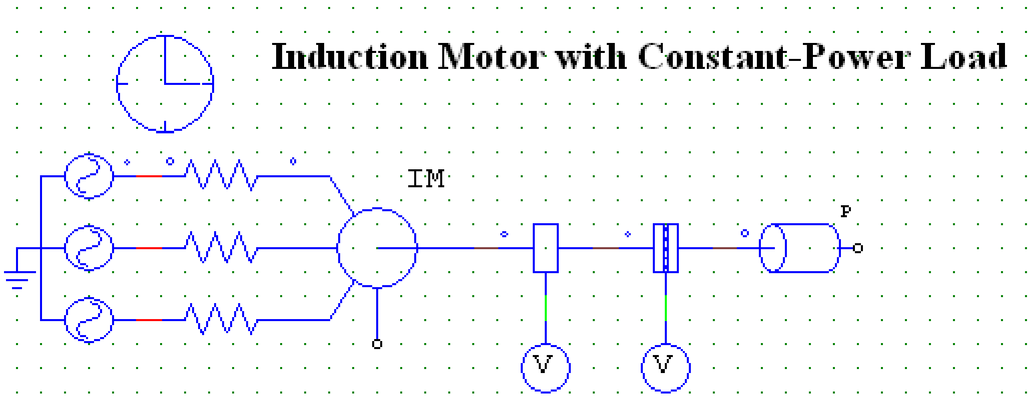
CIRCUIT-32



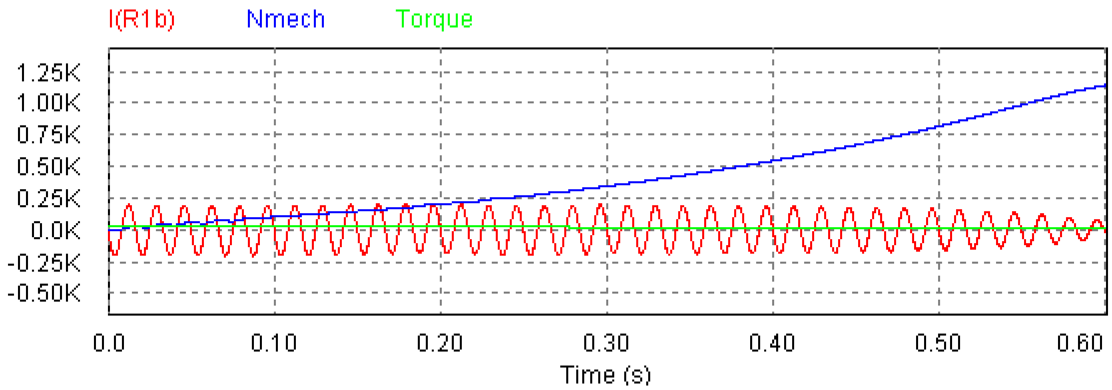
GRAPH-32

33) INDUCTION MOTOR WITH CONSTANT POWER LOAD:

By increasing the stator frequency above its nominal value, it is possible to increase the motor speed beyond the rated speed. In most adjustable-speed drive applications; the motor voltage is not exceeded beyond its rated value.



CIRCUIT-33

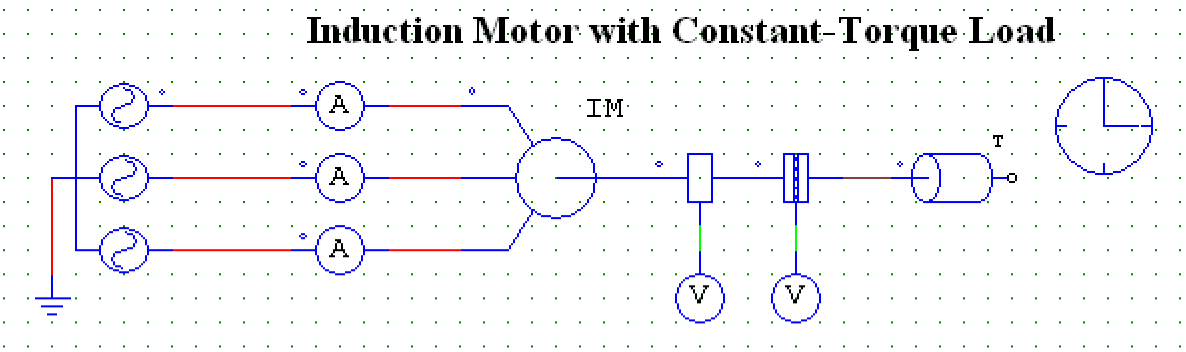


GRAPH-33

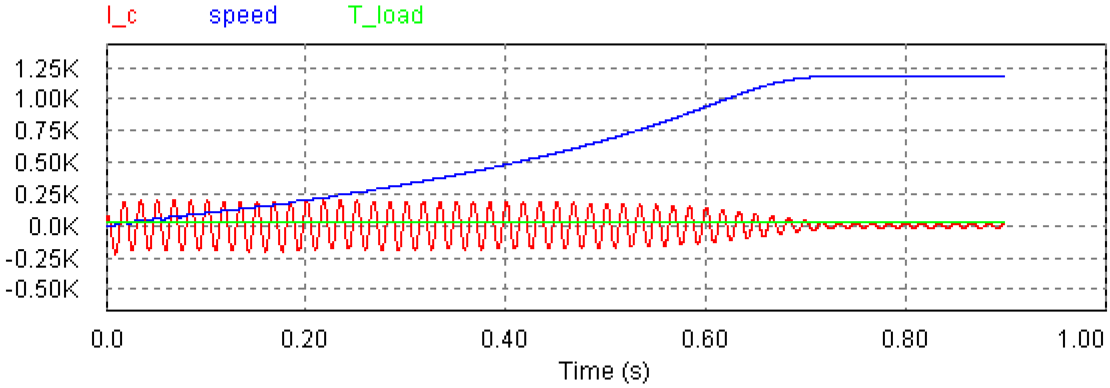
34) INDUCTION MOTOR WITH CONSTANT TORQUE LOAD:

If flux is maintained constant, the motor can deliver its rated torque on a continuous basis by drawing its rated current at a constant frequency. The region below the rated speed is called the constant-torque region

.



CIRCUIT-34



GRAPH-34

3.8 Semi-Conducting Devices:

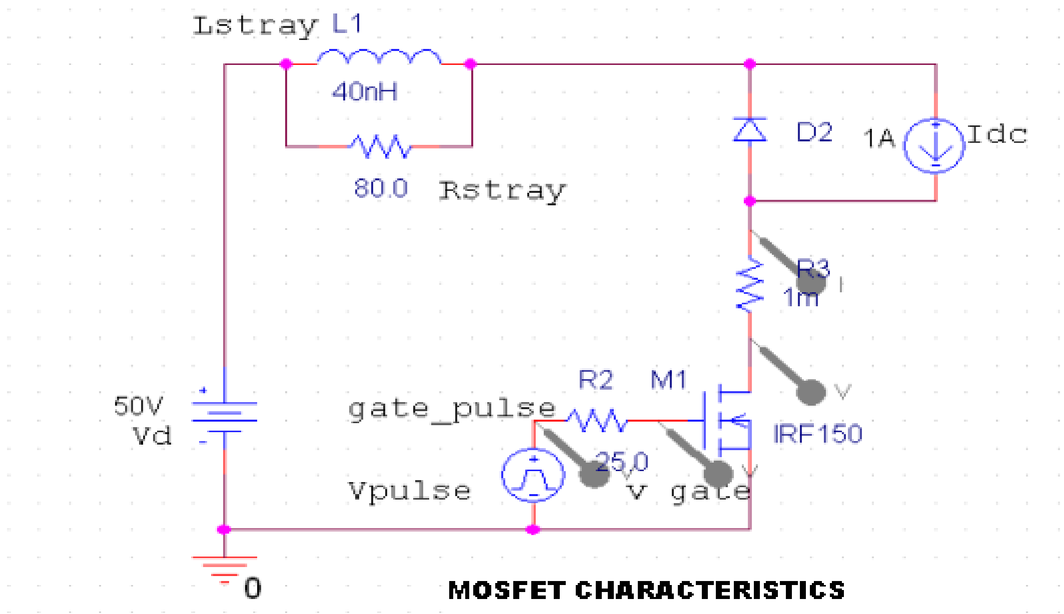
The increased power capabilities, ease of control, and reduced costs of modern power semiconductor devices compared to those of just a few years ago have made converters affordable in a large number of applications and have opened up a host of new converter topologies for power electronic applications. And to understand the feasibility of these new topologies and applications, it is essential to be aware of the characteristics of these devices.

Circuits-

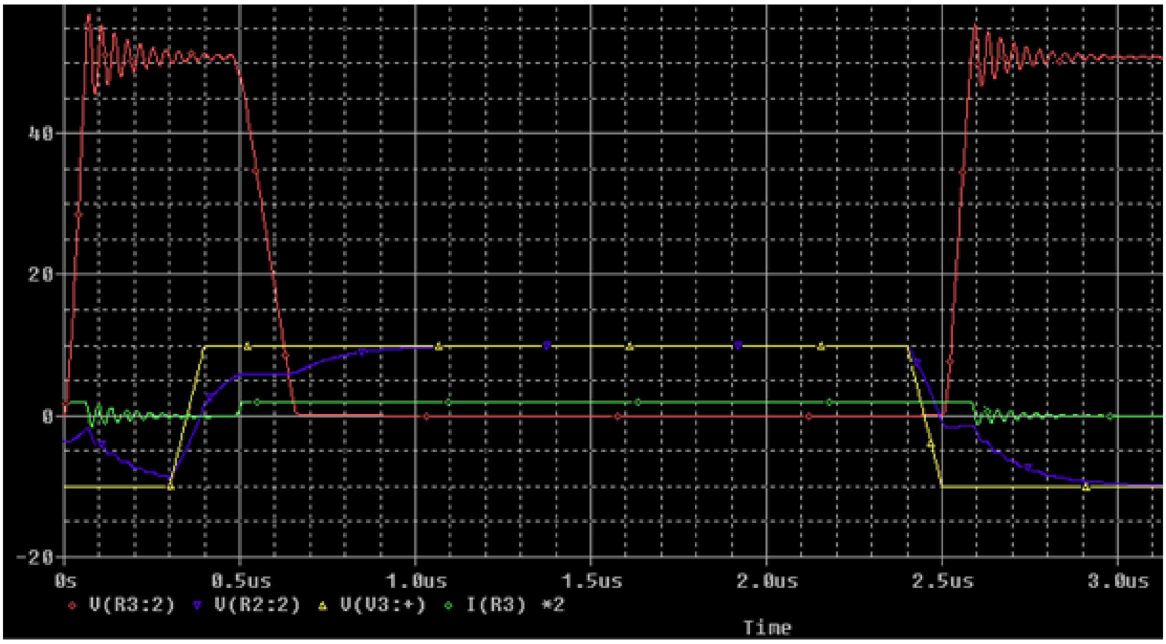
35) POWER MOSFET Switching Characteristics.
36) Bipolar Junction Transistor Test Circuit.

35) POWER MOSFET SWITCHING CHARACTERISTICS:

MOSFET is a voltage controlled device. It approximates a closed switch when the gate-source voltage is below the threshold value. It requires continuous application of a gate-source voltage of appropriate magnitude to be in on state. The switching times are very short, being in the range of a few tens of nanoseconds to a few hundred nanoseconds.



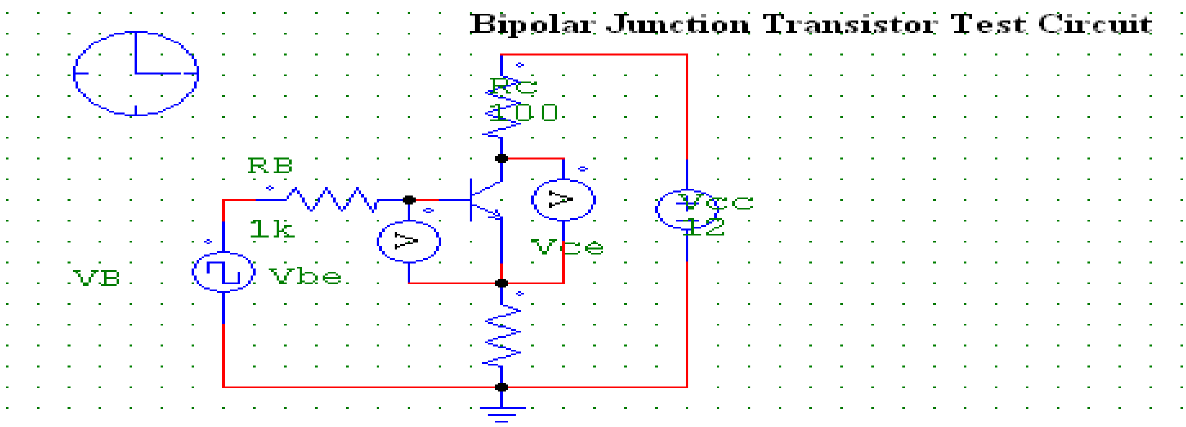
CIRCUIT-35



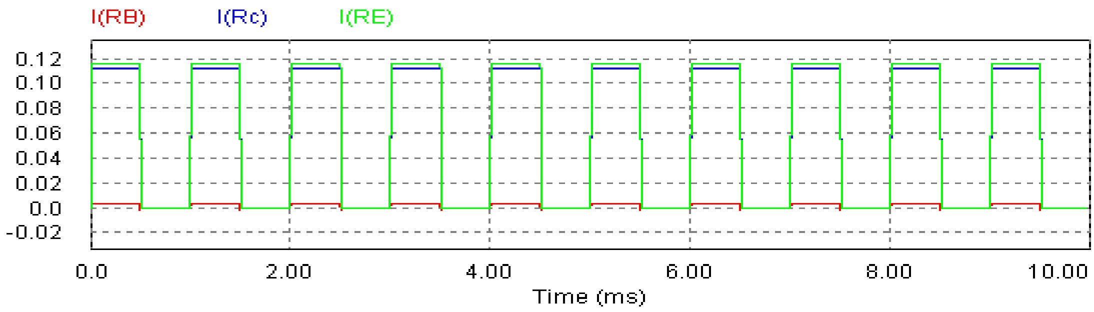
GRAPH-35

36) BIPOLAR JUNCTION TRANSISTOR TEST CIRCUIT:

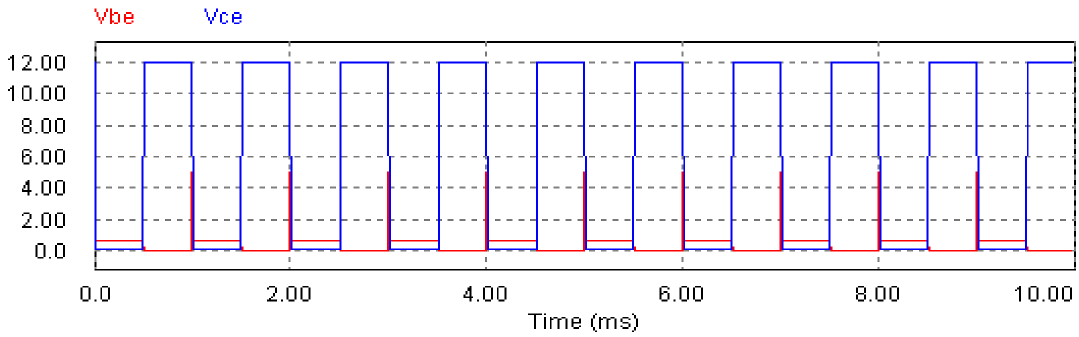
BJT is a current controlled device. A BJT requires a sufficiently large base current to be in fully on-state. The on-state voltage is usually in the 1-2 V range so that the conduction power loss in BJT is quite small.



CIRCUIT-36



GRAPH 36.1(CURRENT)



GRAPH 36.2(VOLTAGE)

4 CONCLUSION

Power Electronics is an enabling technology for all kinds of alternative energy utilization, sustainable mobility, high productivity manufacturing and energy efficiency. The highly dynamic developments in the field bring new challenges like interdisciplinary research, collaboration in international teams and international hiring. These could all benefit from insight into the power electronics and the required extensions to related domains like power systems, mechanical engineering, and material science. Power electronics is an area where simulation aids provide many advantages, both in engineering design and in engineering education.

Today’s computer technology enables a new approach to this work which has not been considered feasible before. Simulation programs will run on inexpensive machines and be widely available. Circuits will be specified in a simple graphical format which is self-documenting. Models will be available to meet today’s needs and yet be sufficiently versatile to be adapted to new devices **as** they appear. By means of a suitable choice of simulator elements, even the inexpert user will be able to customize his package to incorporate future device developments. The simulation models of various power electronic circuits have been developed by using PSpice and PSim software.

PSIM is a simulation package specifically designed for Power Electronics and motor control. PSIM provides fast simulation and friendly user interface. The basic PSIM package consists of three programs: circuit schematic program, PSIM Simulator, and waveform display program SIMVIEW. In addition, there are three add-on modules for PSIM: Motor Drive Module for motor drives, Digital Control Module for discrete systems and digital control, and SimCoupler Module for co-simulation with Matlab/Simulink.

PSpice and PSim models of single and three-phase rectifiers, **PWM** choppers and inverters, AC choppers, Resonant Converters and **DC Drives** are developed. With the aid of Simulation package a menu has been prepared to classify the power electronic networks. The simulation method has been found to be simple and versatile, since governing equations and functions of each power electronics circuit can easily be represented in blocks. The developed software enables the designer to change the parameters or the modulation methods of the circuit. The input and output current and voltage waveforms could be seen momentarily for number of different operation conditions. This study would be useful for obtaining the performance waveforms of numerous power electronic circuits and for more complex systems containing power electronic circuits.

5 FUTURE WORK

"In today's market, there is a huge demand for more automated, functional and higher-performing products. In order to satisfy this demand, engineers must now address the convergence of electronics, mechanics and control engineering when designing a product - whereas in the past they could concentrate solely on a single discipline. Using the software's modelling features and communication backplane technology, engineers are able to construct virtual prototypes of all aspects of a system including the electronics, sensors/actuators, motors, generators, power converters, controls and embedded software. The software enables engineers to investigate system functionality and performance and to verify overall design. The result is a reduction in development time and cost, increased system reliability and performance optimization.

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